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February 11, 1932

Western Hills Viaduct Over Cincinnati Railroad Terminal

Maintaining Irrigation Canal Banks by Disking

Double Piers for Expansion in Rigid Frame Bridge

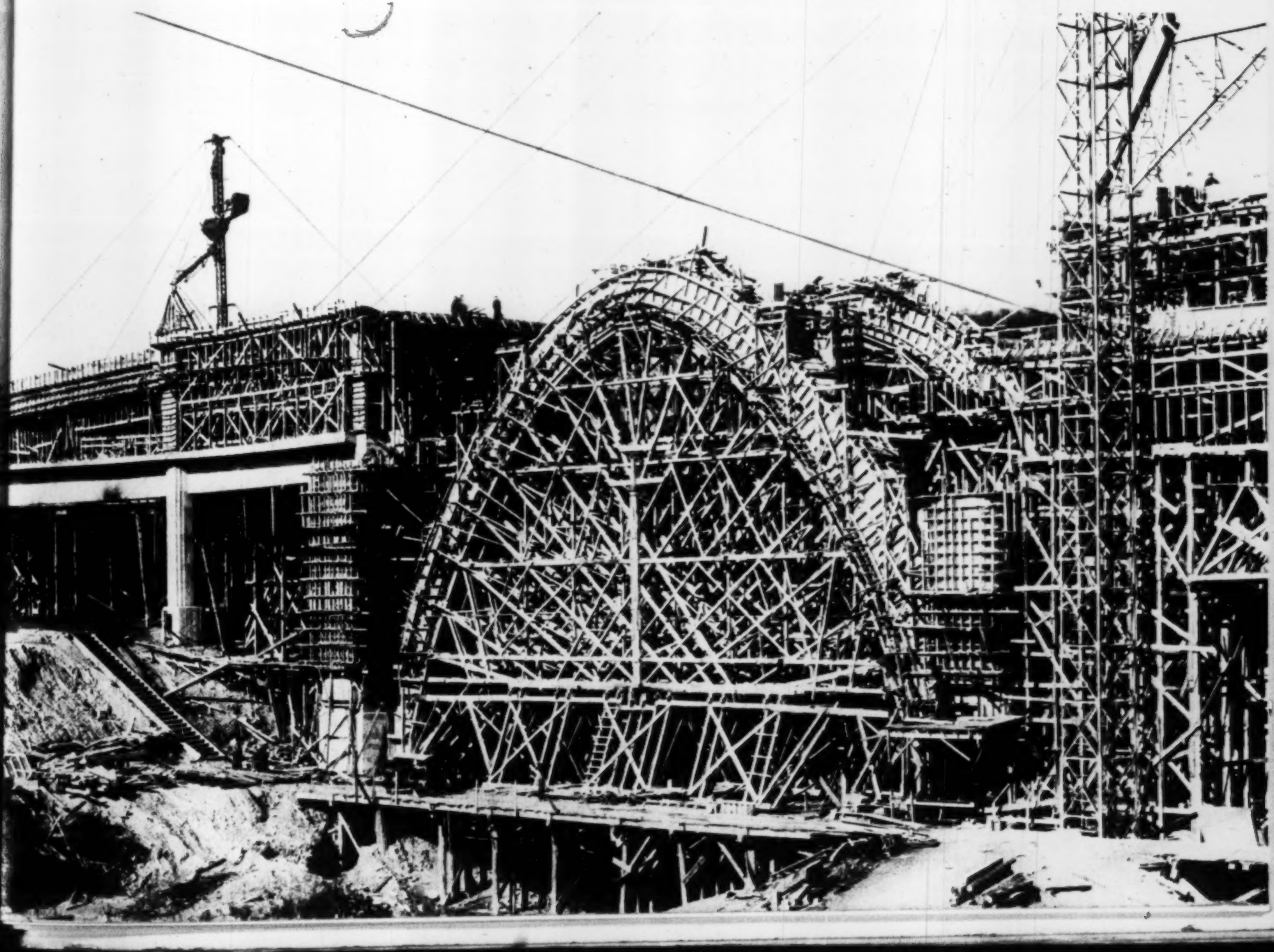
Protecting Wood Structures Against Marine Borers

Buttress vs. Solid Gravity-Section Dams

New Form of Dam for Narrow Rock Canyons

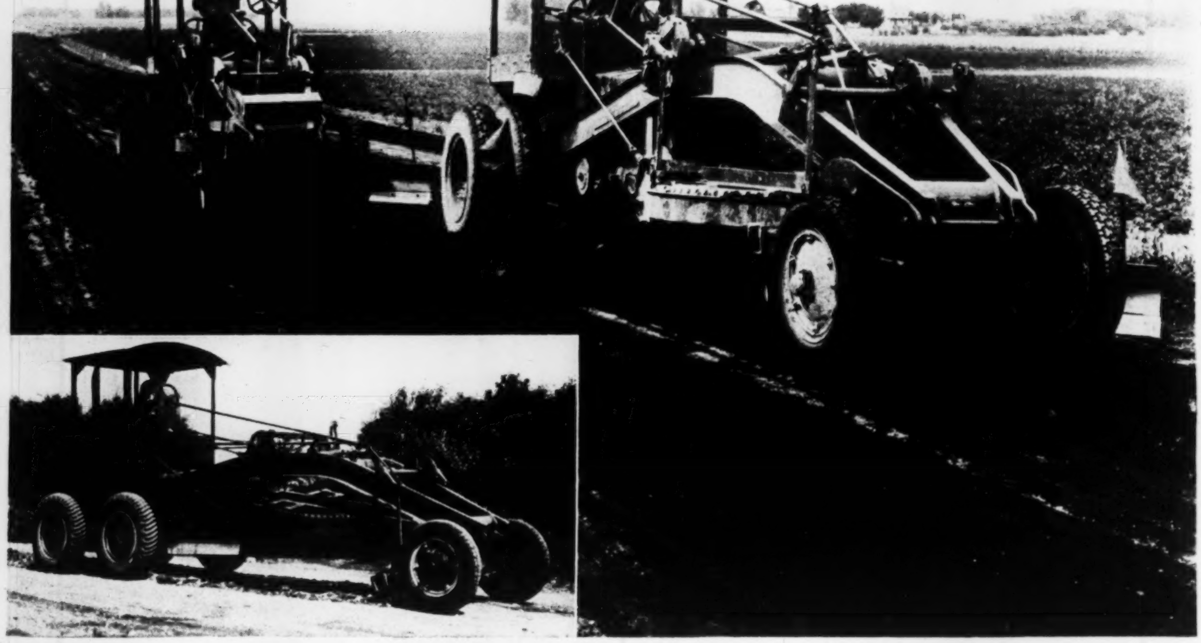
Building Spandrels of Aluminum Alloy

California's 4,000,000-lb. Testing Machine



Timber falsework for [illegible]-ft. concrete arch over Mill Creek in Western Hills Viaduct at Cincinnati, Ohio.

CAPACITY—DURABILITY



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F. E. Schmitt, Editor

Volume 108 New York, February 11, 1932 Number 6

Put the Money to Work!

CALLING idle money back into circulation is an admirable step, for money that is put away in the sock or the safe-deposit box serves only its owner instead of helping to pump the lifegiving flow of credit, business and jobs. If the appeal against hoarding made at Washington last week succeeds in bringing money out of its hiding places, and *if the money is put to work*, it will revive the failing well-springs of credit on which thousands upon thousands depend for their livelihood. The money must be put to work, or it is useless.

Never was it more essential than now that money be put to work. Construction is being shut down by cities and states under the pressure of necessity imposed by failing credit. Retrenchment in construction is becoming a popular movement. As a result there is imminent risk that public work will be throttled down to the halting pace of private construction and business.

DURING the last two or three weeks the financial troubles of cities resulting from slow tax collections, tight credit and banker pressure have become widely known. Cities have reduced their forces and abandoned improvements. Now the federal government shows signs of joining in the movement. Congress is threatening to decrease roadbuilding funds from the promised $125 millions, not only to the normal $75 millions but down to $60 millions. And states are following a like course.

NEW YORK STATE'S authorities are debating a reduction of appropriations that may almost wipe out roadbuilding during 1932. New Jersey is considering diversion of millions of gasoline-tax money to local authorities, though by such action it would reduce the season's road construction to a small fraction of last year's work. Ohio, Michigan and other states that drew on 1932 funds in order to carry on winter unemployment operations must cut down on construction unless they obtain new money. And, as recent examples have shown, new money is reluctant to come forward; states as well as cities have had the experience of receiving no bids on bonds offered for sale, even at 5 and 6 per cent.

We are all for economy, in its proper time and place. But we are against false economy. Throwing workers out of employment and swelling the armies of the jobless is ruinous economy at the present juncture. It does not reduce public expenditure. It merely shifts the expenditure to the unproductive breadline account.

SOME facts just brought out by the New Jersey highway builders' group reveal in definite terms the relation of public work to employment. By analysis of actual operations it was found that not less than four-fifths of the roadbuilding dollar is paid out as wages. Thomas H. MacDonald recently gave a similar figure. Indeed, in all construction work nearly the whole expenditure goes into the worker's pay envelope, whence it travels to trade and industry in widening circles.

If public works are cut off, these wage-payments stop, and the workers become the general charge of the community. New Jersey had forty thousand men engaged in the roadbuilding industries last year, and stoppage of road work will add the larger part of these same thousands to the state's roll of unemployed. A problem of sound public-works finance will thus be converted into a dubious problem of relief and charity.

FROZEN credit is responsible for the threat of widespread cessation of public-works construction. Banks have been unable to provide money. Bank policies and bank failures in turn have tended to convert the investor into a hoarder. But the Reconstruction Finance Corporation, just set up in business, is now engaged in making money freer. The President's call to return idle money to circulation may give further help.

All the money thus brought into the market has immediate opportunity to be useful in maintaining the three-billion-dollar volume of public construction on which the country subsisted during 1931. There is some work for money to do in private enterprise, but its first and greatest service lies in keeping up the public works construction of cities and states.

Adequate credit is the solution of the present problem—whether through the normal sources of finance or through the relief money bills now in Congress. Now that money is in sight, therefore, let it be put to work. Let it be used to provide credit for continuing the construction of public works, almost the sole creative activity that is at our command today.

Leading Articles

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NOTES OF THE WEEK

Earthquake Safety

IN THE great compendium of information on earthquake damage just published by John R. Freeman he estimates that any given area of 25 square miles in the United States east of the Rockies would experience a destructive earthquake only once in 5,000,000 years. The West Indies do not share this high degree of security, for a large part of the group lies in a belt of known seismicity, and therefore the destructive Santiago earthquake of last week, though near our southeastern border, has little meaning with respect to our own hazards beyond emphasizing our protected position. But it suggests a further citation from Mr. Freeman's treatise: "Earthquake-resisting construction is feasible, and is not unduly expensive." This fact, an essential teaching of the entire book, needs to be made general public knowledge. Everyone ought to know that most of the structures which have been damaged by earthquakes in all parts of the world were of weak, inferior construction; that well-built structures have generally withstood earthquake shock; and that buildings can be built substantially earthquakeproof at small increase in cost. When these truths are widely appreciated and applied we may feel doubly assured in our security against earthquakes —a relative security after all.

Starting the Ball

THE Pennsylvania Railroad starts the reconstruction ball rolling by an announcement that it will apply to the Reconstruction Finance Corporation for funds to finance the continuation of its electrification and terminal rebuilding program. The Wabash already has applied for a loan, but that loan doubtless will not show up immediately in new construction, as the railroad is in receivership. The loan to the Pennsylvania, if made, will go directly into buying labor and material and so will get into circulation more quickly. Other railroads which are financially sound can help in like manner to turn the tide. Even though they do not feel justified in going into new construction as heavily as the Pennsylvania, they can undertake lesser improvements and deferred maintenance work. With increased freight rates and decreased wages, coupled with the prospect for abandonment of the upper limit on their income set by the Transportation Act of 1920, the railroads are much more favorably situated today than many other industries. They can help now when others cannot. The electric utilities also have an unusual opportunity presented to them to undertake modernization if not expansion work. If the Reconstruction Finance Corporation is to be a real help in bringing an end to the depression, more of these industries which can put its funds to productive work must plan to do so at once.

The Obligation of Efficiency

A RECENT ruling of the Utah Supreme Court adds to our repeated contention that in the spending of the public's money for improvements an obligation exists to give the public full economic value, even in work done for unemployment relief. Salt Lake City a taxpayer's suit against a sewer project which stipulated hand labor resulted in the court's decision that the city commission had exceeded its authority in deliberately increasing the cost to the public, and that the restrictions invalidated the contract. The motive of the commission to provide maximum relief of unemployment cannot be questioned. Municipal efforts to relieve hunger and privation are to be commended. With the growing reluctance on the part of the public to prosecute any improvements for the time being, the Utah decision is a caution that, although funds voted for unemployment or relief can be legally spent for such purposes without restriction, all money voted for carrying out a public-works project, even where understood to be a relief measure, cannot legally be restricted and made to perform a double duty. The voting of money for public works carries with it the obligation upon officials to prosecute the work in a manner to secure the greatest use of public funds.

Progressive Invention

UNDER the stress of ever greater demands on the art of dam construction, ingenuity in design and invention is unusually active and fruitful. Such activity has been noticeable most strongly since the calamitous St. Francis failure in 1928, but even before that demonstration of the complexity of dam behavior and hazard there had been intensive thinking on the problems of the great storage structures which modern service finds necessary. Refinement of buttress types, subdivision of gravity structures as in the Don Martin dam, improvement of knowledge of hydrostatic underpressure, attention to drainage, and increased thoroughness of geologic studies are major factors in this thinking. Earthquake disturbances also have been given consideration. The West has been and remains the leader in progress in the field of dams, as it also made the greatest steps in modern analysis by the trial-load method and in its application to combined gravity and arch dams. The remarkable thrust buttress design presented by C. H. Howell this week adds another contribution to this record of progress. Its simple but thoroughly grounded conception offers a way of escape from many difficulties that have assumed a controlling position in present-day projects requiring high dams. It invites careful consideration for this reason as well as because of its place in the noteworthy current advance of thought in the field of dams.

Building Wages

IN APPRAISING the meaning of the numerous current movements to reduce wage scales in the building trades it must be recalled that the scales have risen steadily since 1913. Up to the past year they were generally observed, but under the pressure of widespread unemployment and falling commodity prices and in the face of a poor building market they have recently broken very extensively. William Green, president of the American Federation of Labor, reported in our pages last week that at the close of the year 62 per cent of building labor was out of work, a figure that is to be compared with 23 per cent unemployment in all industries. A summary of actual building wages, in the same issue, showed that on Dec. 15 in 66 cities they averaged nearly 26 per cent below set scales. The second condition is a natural result of the first. Hence the general demand for a lowering of wage scales. New York is the latest to come forth with such a proposal, the employers there advocating reductions of 25 to 30 per cent. Elsewhere the unions have realized the advantage of more work at less wages over less work at higher pay, and have volunteered lower scales. Whether a lowering of labor costs, accompanied by lower material prices, will revive demand for a nearly stagnant activity remains to be seen. However, it is certain that reduction of scales in line with actual wages will discourage rebating, secret scales and similar practices that are adding to the distress of an already harassed industry.

Progress and Creative Effort

TIMES of stress like the present are notorious disturbers of established habit. Social, economic and political conditions undergo change, and with them the foundation on which rest technological production and trade systems. Such transformation of beliefs and wants has been in active progress during the past year or two and doubtless is still continuing. It has profound meaning for industry and the engineer's work. It tells us that progress will be shaped largely by creative effort, and that research is a vital agency of success.

New times are ahead, but the conditions that determine them are old in history. Much of the great creative work of the past blossomed from the hard soil of poverty and need; though ease may bring refinement and the high color of art, yet invention has always been the outgrowth of necessity. Now, after the world has been engaged in refining, amplifying and applying throughout half a dozen years of prosperous production, the present period of pressure and strain throws it back on the resource of new thinking. Out of the doubts and struggles of the moment must grow that creative thought and enterprise which can direct our labors.

It was well said by Willard Chevalier in addressing the recent gathering of the Highway Research Board that today the civil engineer is far more concerned with the problem of survival than with some of the more technical problems that have faced him during the last ten years. "We must take our generally accepted ideas down from the shelf, dust them off, and inspect them," Col. Chevalier asserted. And this remark, though pointed at the arts and industries of highway construction, applies with like directness to every branch of industry or profession in which civil engineers are active.

Creative thinking is vital to the individual; creative research is vital to organization and industry. The accustomed things of the bustling days of prosperity may not hold their place tomorrow, in the day of new activity. The same job may not be wanted; if it is wanted, better ways of doing it will be expected. Will the highway programs of five years back suit next year's demands? Are cities going ahead in future on the random planning methods of the past? Are bridges and port developments and plant extensions to grow out of inspiration or impulse as hitherto? We cannot tell to what extent, but we know that change in these conditions will react profoundly on the engineer's work.

At present the outcome of many of these doubts and questionings remains uncertain. Some will disappear when minds and credit return to normal balance. Others are deeper seated and in one or another form will have lasting influence. Housebuilding, for example, has been subjected to a challenge that will have answer. Public-works and local-improvement planning face new days. Economy of construction, lessened extravagance and jazz in design are probable. A drift toward weight reduction in bridges as in building floors and other structures may make further headway. And, looking at a broader field, craft and industry groups can hardly escape the new responsibilities of service that current thinking is ready to assign to them. So throughout the range of engineering interests it is timely to be prepared for new demands and new ways of adapting acquired skill.

For industry this means very plainly intensified recognition of research. It may well be a different research from that of past years, less concerned with production and refinement and more with creation of new services, but it will prove far more vital. How quickly industry regains momentum after its stagnation will be determined largely by the virility of thought applied to its work, not alone in the pioneering generalship of new leaders but as well in the penetrating originality of research.

Construction's Problem

THE remarkable picture of the dependent and unorganized state of the construction industry which was outlined in last week's articles by Robert D. Kohn, Gen. R. C. Marshall and William Green sets forth the prime problem confronting construction—to achieve integration, unity and plan. Until the past year little attention was given to this problem. Now it is the subject of thought by many men of different occupations.

"Return of the building industry depends on making construction a safer and sounder investment," Mr. Green said. Unconsciously replying in part to the challenge contained in these words, Mr. Kohn stated: "We can get started right now on doing certain things. . . . We can coordinate our efforts. . . . We can get at the facts regarding real needs for building work, and we can find a way to finance some of them." To serve this work, Gen. Marshall pointed out, "the best brains for collective thinking are available."

These thoughts are guideposts to progress. If the arts of construction set themselves the objective of making building a sounder investment, if they start now and by coordinated effort determine the facts about building needs, and if they apply their full abilities to collective thinking the road ahead will be clearer. Advancing along that road, construction can become the leader where now it is the mere servant of other interests. It can stabilize itself and help other industry to attain the stability now so sadly lacking.

But construction if it is to perform its major task as a stabilizer of industry is required to do two things—get away from its provincial thinking and tax itself for the funds to build a national structure. It has never thought of its problems except factionally—labor, contractor, engineer, banker and owner have each conceived of the others as an opponent to be worsted if possible. Each has taxed himself only to advance himself, but never to advance the industry of which he is merely a component factor.

Thus the industry's whole scheme of existence has been and is based on the concept of clan organization, not on federation or united purpose. Construction's first task, then, is to conceive of itself as an industrial unit and bring its separated units into coalescence. Its next, to support and maintain this unity by joining its resources and effort for the sound planning and direction of the industry's work.

Double-Deck Viaduct Built Over Cincinnati Terminal

Concrete two-rib open-spandrel arches and steel spans make up Western Hills viaduct upon which difficult foundation problems were solved

A DOUBLE-DECK VIADUCT, 3,500 ft. long, of reinforced-concrete and concrete-cased structural steel, crossing the Mill Creek valley at Cincinnati, is the solution of a difficult street-traffic and grade-separation problem arising from the construction of the new union passenger terminal and rearrangement of freight facilities, as described in *Engineering News-Record*, Feb. 26, 1931, p. 348. This railway development necessitated the removal of two highway viaducts and the closing of two streets crossing the site at grade. Better communication between the city and its rapidly developing residential section on the heights across the valley will be provided by the new Western Hills viaduct, which will also connect with McMillan St., an important cross-town thoroughfare. This viaduct was opened to traffic on Jan. 16, 1932.

It is estimated that this viaduct will provide ample capacity for the traffic until 1970, when additional crossings may be necessary. The structure has been designed in accordance with the specifications of the Ohio state highway department, using a live load of 20-ton trucks and 50-ton street cars. The 120-ft. arch span carrying the single-deck part of the structure over Spring Grove Ave. is shown in Fig. 1, while Fig. 2 gives a plan and profile of the entire structure.

The upper level, which will carry the high-speed vehicular traffic, extends west from Central Parkway, a wide and heavily traveled boulevard, to Harrison Ave. near Beekman St. It has a 40-ft. roadway and two 6-ft. sidewalks. The lower level, which will carry street-car and truck traffic, extends from Spring Grove Ave. to Harrison Ave.; it also is 40 ft. in width but has no provision for pedestrian traffic. From bents 25 to 50 galleries have been provided outside the main structure at the elevation of the lower roadway, one on each side, to carry a 36-in. water main and a 30-in. gas main across the terminal area. Two concrete arches are introduced for long spans.

At the west approach a wide plaza, designed to separate and distribute the various classes of traffic, is being provided. Traffic on the lower level will reach this plaza by means of ramps, one on either side of the main viaduct, while street-car traffic from the lower level will pass under the plaza and reach the street grade beyond by means of two approaches between retaining walls. This approach presented many interesting problems in its details, on account of the complexity of the street-railway intersection, the irregular shape of the area and the necessity of maintaining traffic across it during construction.

Architectural Treatment and Lighting—Careful attention has been given to the architectural appearance of the structure, the architects and engineers working in close collaboration for the purpose. The treatment is modernistic in style, with a minimum of applied ornamentation, and with emphasis placed on vertical lines and surfaces. Considerable care has been taken to keep the treatment uniform, so that the finished structure may present the appearance of a complete whole rather than a composite. Pylons carrying lanterns mark the ends of the structure and the abutments of the arch spans. To give a good surface finish, the exposed surfaces of concrete are rubbed with carborundum blocks. An open design of parapet wall (poured in place) is used for the upper deck, while the lower deck has solid parapet walls with paneled faces.

The absence of trolley poles on the upper level gave the incentive to the search for a type of lighting that would eliminate the need for the usual lighting standards. The type adopted makes use of fixtures recessed in the dies of the balustrade and employs a lens designed to concentrate the light on roadway and sidewalk surfaces. Extensive experimentation indicates that it will be quite successful. For the lower deck, bracket lights attached to the columns will be used where clearance permits; elsewhere, pendant overhead inclosed lighting units will be concealed by the floor beams of the upper deck.

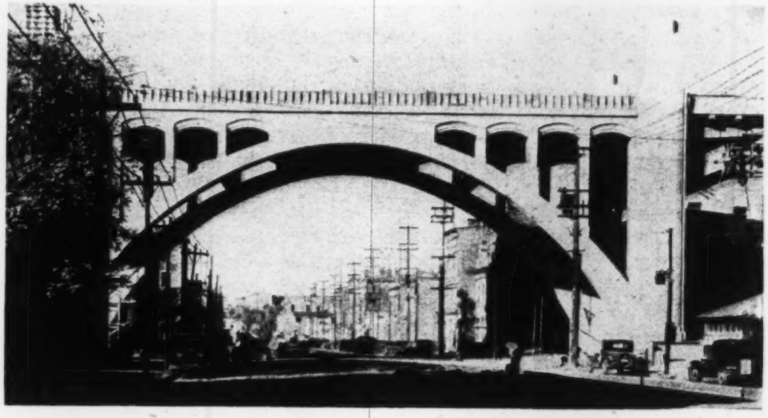


Fig. 1—Arch over Spring Grove Ave., Cincinnati, in single-deck portion of Western Hills viaduct.

Structural Design—With the exception of two arch spans and the west approach, the entire structure consists of a series of two- and three-span frames, with the two columns of each bent connected by a cross-girder at each deck, and with a separate rectangular footing under each column. Longitudinal beams or stringers with lateral struts between them support the deck slab. This design is shown in Figs. 3 and 4. Double bents are used at expansion joints. In crossing the railroads the arrangement of spans and location of piers had to be planned in conjunction with a definite layout of the numerous tracks.

From the east end to bent 22 (Fig. 2) the frames are single-deck, while the rest of the structure is double-deck. The length of span averages 42 ft. for the single-deck portion and 56 ft. for the double-deck portion, with a maximum span of 78½ ft. (exclusive of the arch spans). The height from top of footing to top of roadway varies from 22 to 90 ft.

Except between bents 27 and 47, all of the frames, both single- and double-deck, are of reinforced concrete, with beam and girder decks and floor slabs supported on spirally reinforced columns. Between bents 27 and 47 the frames are of structural steel, incased in concrete, with reinforced-concrete floor slabs. Structural steel was adopted for this part of the structure because the span lengths are too great for economical construction in reinforced concrete and because the ability to support forms from the steel without falsework is an aid to construction over the tracks in this area.

In designing the double-deck concrete frames from bents 47 to 58, it was found necessary to introduce a hinge in each column at the top of the lower deck to relieve the moments induced in the

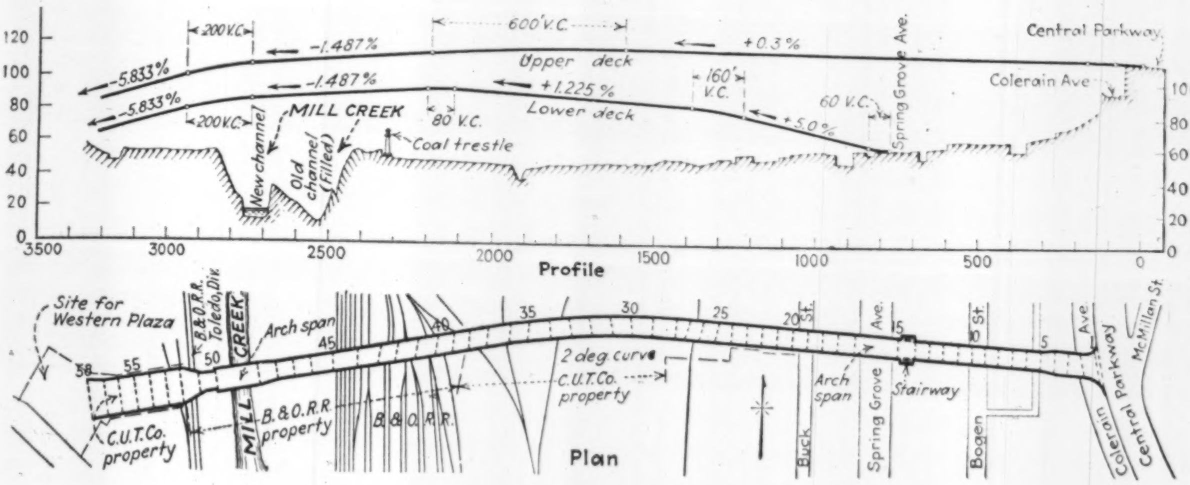

120
100
80
60
40
20
0
200 V.C.
-1.487%
600' V.C.
+0.3%
Central Parkway
-5.833%
Upper deck
-5.833%
-1.487%
+1.225%
160' V.C.
Colerain Ave
200 V.C.
MILL CREEK
80 V.C.
Lower deck
60 V.C.
+5.0%
Spring Grove Ave.
New channel
Old channel (Filled)
Coal trestle
3500
3000
2500
2000
1500
1000
500
0
Profile
Site for Western Plaza
B.&O.R.R. Toledo Div.
CREEK
Arch span
58
55
50
45
40
35
30
25
20
15
5
2 deg. curve
C.U.T. Co. property
MILL
B.&O.R.R. property
B.&O.R.R.
Plan
Buck St.
Arch span
Spring Grove Ave.
Stairway
Bogen St.
Colerain Ave.
Central Parkway
McMillan St.

Fig. 2—Western Hills viaduct, Cincinnati, a 3,500-ft. double-deck structure built to carry traffic over the new railroad terminal tracks.

columns by the frame action. This hinge consists of a steel lower casting with its top surface machined to a convex spherical segment, and a steel upper casting with the lower surface machined to a concave spherical segment of a slightly larger diameter. A steel pin connects the two castings on the vertical axis to aid in transmitting the horizontal shear. These hinges are entirely concealed in the column concrete.

In the steel portion of the structure the framing consists of I-beam stringers supported by trussed floor beams framing into main longitudinal trusses. These trusses are framed into the columns with connections designed to transmit the moments induced by frame action into and across the columns. The lower-deck main trusses are of the half-through type, with the upper portion of the truss incased to serve as a parapet; the upper-deck main trusses are entirely below the deck. On account of the long spans the two levels of roadway and the limitation of two columns to a bent, the steel column sections are extremely heavy. Each column is of built-up H-section, with plate and angle web and I-beam flanges, the complete steel column having a maximum weight of 1,285 lb. per foot, including details.

Concrete Arches—There are two reinforced-concrete arch spans, one of 120-ft. clear span and 41-ft. rise over Spring Grove Ave. and the other of 109-ft. clear span and 62-ft. rise over Mill Creek. While foundation conditions were not ideal for arches at these locations, careful study indicated that arches were the most economical type for providing the long spans required at these two points.

The Spring Grove Ave. arch (Fig. 1) is a single-deck open-spandrel arch with two ribs having a maximum section 6 ft. square. The Mill Creek arch (Figs. 5 and 6) has two decks, is of open-spandrel construction and has two ribs with a maximum section 7 ft. deep and 6 ft. wide. It has the central portion of the lower deck hung from the arch rib, while the rest of this deck and the entire length of upper deck are supported on spandrel columns. Every effort has been made in the design of both arches to minimize the restraining effect of the deck on the ribs.

In order to take care of the horizontal thrust of the arches, which in the original design had been provided for by batter piles in the case of the Spring Grove arch and batter piers for the Mill Creek arch, it was decided to construct a tension tie under each rib in order to connect the footings, and the proposed batter supports were eliminated, as noted later. These ties (Fig. 5) consist of groups of $2\frac{3}{4}$-in. steel rods varying in length from 16 to 47 ft., which have upset ends and are spliced by means of turnbuckles. The rods are incased in concrete, which is carefully treated with membrane waterproofing. They extend into the footings far enough to develop their stress in bond, and in addition they are in bearing against steel channels buried in the foot-

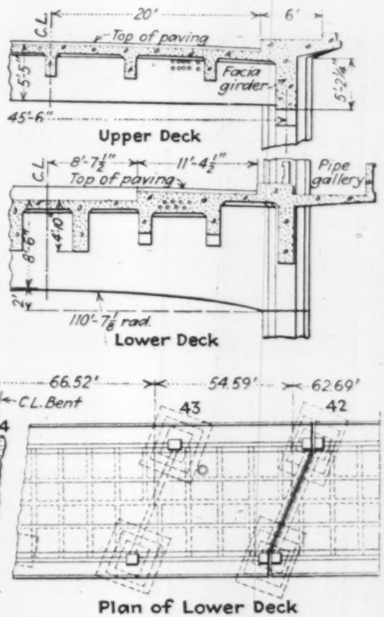

C.L.
20'
6'
Top of paving
5'-5"
Facia girder
5'-2¼"
45'-6"
Upper Deck
C.L.
8'-7½"
11'-4½"
Top of paving
Pipe gallery
4'-0"
8'-6"
2'
110'-7⅞" rad.
Lower Deck

Fig. 4—Cross-sections of viaduct. Depressed roadway slab of lower deck provides for street-car tracks.

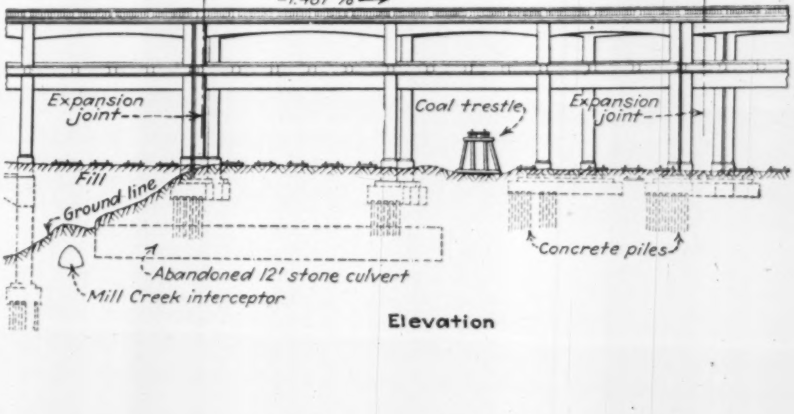

68.86'
78.50'
66.52'
54.59'
62.69'
C.L. Bent
C.L. Bent
C.L. Bent
46
45
44
43
42
Plan of Upper Deck
Plan of Lower Deck
-1.487%
Expansion joint
Coal trestle
Expansion joint
Fill
Ground line
Concrete piles
Abandoned 12' stone culvert
Mill Creek interceptor
Elevation

Fig. 3—Portion of Western Hills viaduct in which concrete-incased steel frames are used because of long span lengths and as an aid in erection over the railroad tracks.

ings. No attempt was made to place initial tension in the rods other than to insure that they were in perfect alignment and that all slack was taken out of the connections. The arch ribs were designed for the stresses induced in them by elongation of the tierods.

Subsoil and Foundations—Geological or subsurface conditions at the site were such as to require careful study to determine the proper types of foundations. The structure crosses a wide valley originally occupied by the Ohio River, which was subjected to glacial action during the later geologic periods, causing the Ohio River to be diverted to its present channel. At the present time Mill Creek, a small local waterway, occupies the west side. The valley has walls of hard yellow clay and shale in horizontal beds, while its floor is of yellow and blue clay and various deposits of sand ranging from coarse gravel to quicksand. These deposits are irregular in extent and overlay hard shale and limestone at depths varying from 55 to 115 ft. below the surface.

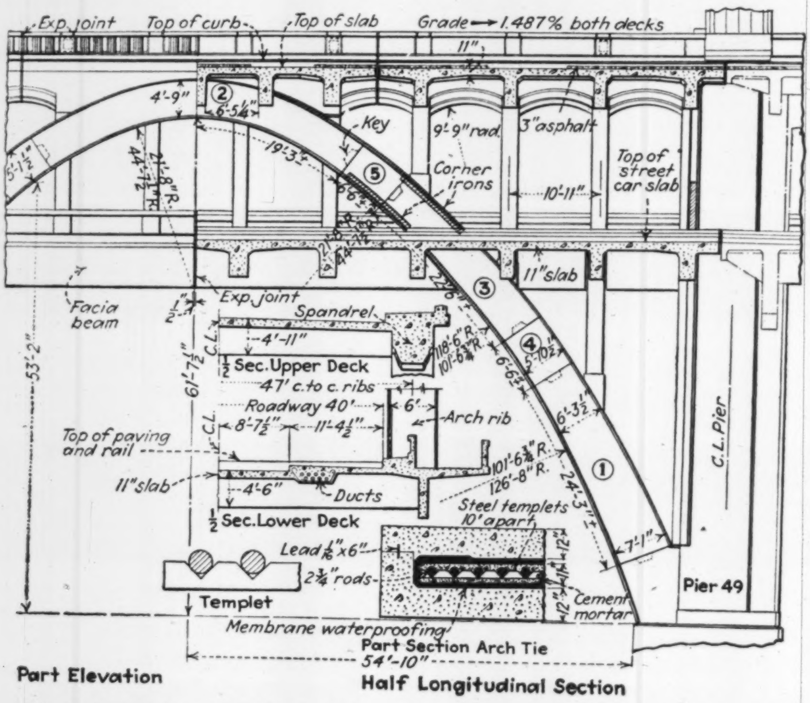


Fig. 5—Arch span over Mill Creek. Note double-deck construction.

The original plans contemplated soil-bearing foundations for bents 1 to 14, inclusive, and from bent 57 to and including the west approach. All other foundations were to be on cast-in-place concrete piles, except that pairs of cylindrical piers sunk to rock were originally designed for bents 44 to 51, inclusive.

Additional test borings, completed about the time work was started, raised a doubt as to the practicability of putting down caissons for these piers by the open-well method, and a few weeks' work by the contractor indicated that their construction by any open method was impractical on account of quicksand. After careful consideration of several alternative plans it was decided to use steel-pipe piles, driven to rock and filled with concrete, as a substitute for the foundation piers. It was also decided to use similar vertical steel-pipe piles as a substitute for the proposed concrete batter piles at bents 15 and 16 for the Spring Grove Ave. arch.

Steel-Pipe Piles — Pipes 20 in. in diameter with $\frac{1}{2}$-in. shell were used, in sections averaging 22 ft. in length, spliced by means of a cast-steel outer ring so as to leave the inner surface smooth. Their allowable load of 170 tons was that specified by the tentative New York building code. These piles were driven with steam hammers in swinging leads suspended from the boom of a crawler crane. They are 50 to 95 ft. in length.

The material inside the piles was blown out with compressed air, water also being used when necessary; after inspection the pipes were filled with concrete. At bent 15, the eastern foundation for the Spring Grove Ave. arch, considerable difficulty was experienced in removing from the interior some of the material encountered, consisting of thin strata of shale and limestone above the elevation at which the piles were to have their bearing. It was first attempted to break this material by dropping a length of T-rail, the lower end of which had been fashioned into a bit, but progress by this method was so slow that the use of well-drilling methods to penetrate the troublesome strata was substituted with success.

Cast-in-Place Concrete Piles — The type of concrete pile used is formed by driving a steel casing, inside of which is a steel mandrel. When the casing has been driven to the proper depth (which does not extend to rock) the mandrel is withdrawn and a corrugated iron shell is placed inside the casing and filled with concrete, after which the steel casing is withdrawn. In most cases the concrete pile has a wooden lower section, which is driven inside the steel casing after the mandrel is withdrawn, but before the corrugated shell is placed. These piles average 24 ft. of wood and 33 ft. of concrete. The joint between the wooden and concrete sections of the composite piles is kept below the water line. For this type of pile the maximum load used in the design is 30 tons.

Heaving of Concrete Piles—From the start of operations a close watch was kept for possible heaving of piles. This trouble soon developed, and a careful study was made to determine what could be done to offset its effect. It was impossible to redrive the piles on account of their nature, but it was found that by a suitable arrangement of tackle a static load of about 40 tons, including a large part of the weight of the driving rig and a load of pig iron, could be applied to each pile. Where heaving occurred, each pile was subjected to this load, which was almost double the average final constant design load. Careful records of the behavior of the piles indicated that the settlement under load was almost invariably smaller than the original heave. In some cases the piles heaved again after being pushed down, but this was usually a very small fraction of the original heave. However, where this second heaving amounted to more than $\frac{1}{4}$ in., the piles were again loaded and pushed down.

In two of the foundations where heaving occurred, excavations were made for practically the full depth of the piling to determine the cause of heaving and the conditions of the piles. These explorations disclosed that the soil between the piles had been compacted to a very dense state, that in some cases the pile had separated at the joint between the wooden tip and the concrete section, and that in other cases the concrete section had pulled apart for its entire area. The heaving was undoubtedly due to the fact that the earth was compacted to the limit of compressibility, and further driving caused the soil to heave, moving the piles with it.

Construction Work — The contract for the entire structure, excepting the west approach, was awarded early in November, 1930. The contractor concentrated on excavation, piledriving and concreting of foundations during the winter. He used a crawler crane equipped with a clamshell bucket and had as many as five piledrivers at work simultaneously. The concrete for both piles and footings was ready-mixed, bought from a commercial concrete mixing company and mixed either at a central plant or in transit on trucks equipped with mixers.

The principal difficulty encountered in winter concreting of the footings was in placing and holding the anchor bolts for the structural-steel portion of the structure. There were either four or six heavy anchor bolts in each foundation. As each footing was poured monolithic, the anchor bolts had to be suspended from a timber frame resting on the sides of the excavation. When heat was applied to thaw out the foundation pits preparatory to concreting, there was a tendency for the frame supporting the anchor bolts to shift out of line.

Early in the spring of 1931 work was started on the erection of structural steel and on the construction of the reinforced-concrete frames. Most of the steel was erected by two heavy locomotive cranes with 80-ft. booms, which were extended for certain operations to lengths of 90 and 110 ft. These cranes operated on a temporary track along the center line of the structure. Erection by this method began at bent 27 and proceeded westward to bent 44. On account of main-line railroad tracks and a sharp break in the ground line, the steel thence to bent 47 could not be erected from the ground. Therefore, a traveler placed on the upper deck was used for this portion of the structure, the steel floor system being reinforced where necessary to take care of the erection loads. The maximum load on this traveler was a lift of 50 tons at a radius of 75 ft. A total of approximately 5,300 tons of steel was erected complete between March 11 and June 19, incasement of the steel structure following closely upon its erection. All incasement was of poured concrete.

Forms for concrete work are fabricated in a centrally located shop, transported to the job by truck and lifted to place by a crawler crane. After the forms are stripped they are returned to a yard near the shop, where they are either cleaned and oiled or dismantled and the lumber salvaged.

For supporting the deck of the concrete frames, use is made of timber towers built of units 6 ft. square and 8 ft. high, each unit consisting of four 8x8-in. posts with 2x8-in. top and bottom sills, diagonally braced on four sides. A tower is made by erecting these units one above the other to the proper height, the units being spliced and adjacent towers being braced together for stability. Variations in height are cared for by the use above the towers of adjustable shores of the type ordinarily used in building construction. The advantage of this type of construction is in the facility with which it can be erected, dismantled and re-used.

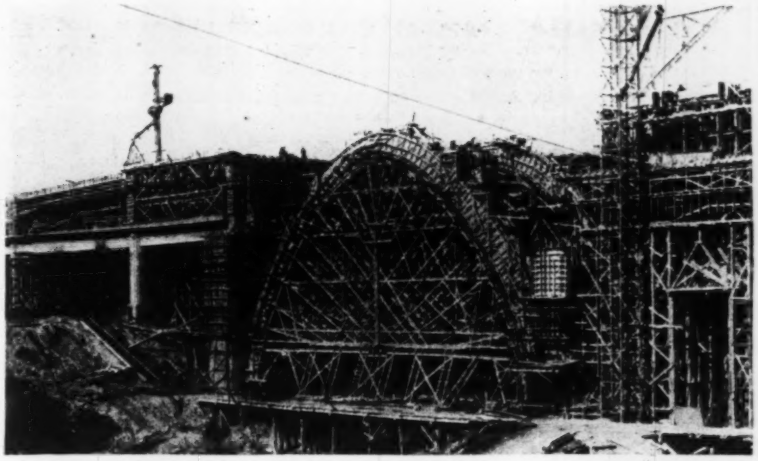


Fig. 6—Mill Creek arch of 109-ft. span was poured in wood forms supported by an elaborate system of timber falsework.

All concrete is delivered ready-mixed, is raised to the site of the work by two steel towers and two mast hoists and is usually chuted direct to the forms, although in some cases a part of it is delivered in buggies. Construction joints are provided in the columns at the bottom of the cross-girders, and all concrete in each frame above this joint is poured as a continuous operation, the maximum volume involved in a single pour being 1,050 cu.yd.

The deck slabs, where the grade is not prohibitive, are cured by ponding, while sidewalks and other exposed surfaces that cannot be cured in this way are covered with burlap and kept continuously wet, the forms being left in place a minimum of seven days to prevent surface drying. After curing, all exposed surfaces of columns, beams and handrail are finished by rubbing with carborundum blocks by hand.

The method of placing concrete on the steel portion of the structure is substantially the same as for the reinforced-concrete portion, except that in a majority of cases the formwork is suspended from the steel frame.

Timber centering for the arches is conventional in design. At Spring Grove Ave. it is carried on mud sills, and at Mill Creek (Fig. 6) on timber piles. Openings are provided at Spring Grove Ave. for traffic and at Mill Creek for floodwater. The arch ribs are poured in alternate blocks, the key blocks (Fig. 5) being poured a minimum of three days after the main blocks are poured.

West Plaza Development—Early in September, 1931, a contract was awarded for the construction of the west plaza. This work involves a change in street grade, amounting to a maximum of 6 ft., the relocation of all utility structures, temporary detouring of street traffic, construction of numerous approach walls, and construction of about 40,000 sq.ft. of flat-slab deck. The contractor worked three shifts in an attempt to complete this contract before extreme cold weather.

Engineers and Contractors — The Western Hills viaduct was designed by and is being constructed under the direction of the Cincinnati Union Terminal Co.; H. M. Waite is chief engineer, George P. Stowitts engineer of construction, Pusey Jones engineer of design, E. D. Tyler architect, and A. H. Sullivan electrical engineer. S. A. McGovren, assistant engineer, had direct charge of the design, and George H. Wells, district engineer, had charge of the construction in the field. The city has been represented by H. F. Shipley, engineer of highways.

The MacDougald Construction Co. is the general contractor for the viaduct proper, with the McClintic-Marshall Corp. as subcontractor for furnishing and erecting the structural steel, and the MacArthur Concrete Pile Corp. and the Pierce Steel Pile Corp. as subcontractors for the piling. The Folwell Engineering Co. has the contract for the west approach.

It is expected that the structure will be open for traffic early in 1932. Its cost, about $3,500,000, will be shared by the city, the Cincinnati Union Terminal Co. and the Baltimore & Ohio Railroad.

◆

British Railways Extending Door-to-Door System of Transport

The door-to-door system of transport is being extended rapidly by British railways, not only for internal use but for cross-Channel traffic as well. The most ambitious undertaking so far attempted, which involves the transport of extremely heavy freight loads, is that of the London & North Eastern Railway, which plans to dispatch a number of its loaded trucks from Manchester to Budapest, a distance of 1,200 miles. Freight cars will be of a special variety, with capacities varying from 20 to 110 tons.

Canal-Bank Maintenance by Disking on Imperial Irrigation District

Tractor-drawn disk supplants hand-cutting of brush and bamboo on 2,600 miles of ditch—Cost cut in half and results more effective—Unit completes 25 miles per month

By M. J. Dowd

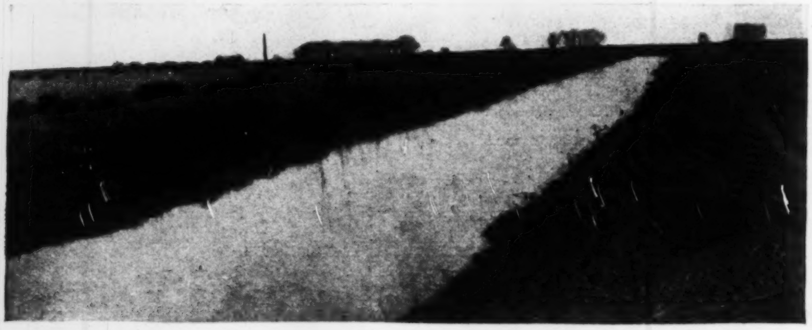
Chief Engineer and General Superintendent, Imperial Irrigation District, Imperial, Calif.

THE MAINTENANCE of irrigation ditches often becomes a more serious problem than that of original design and excavation. Removal of silt, maintenance of economic cross-section and control of plant growth are continuing problems requiring the most vigilant attention of those in charge of operations. Various localities frequently have to contend with an especially stubborn phase of the study, but the Imperial Irrigation District, with its heavily silt-laden water, flat terrain and conditions favoring the most rapid plant growth, is confronted with ditch-maintenance problems that are notable in severity. In the issue of Sept. 25, 1930, p. 501, Mr. Dowd described two machines developed by the district, which had proved very successful in ditch-cleaning and maintaining operations. In the following description he outlines the development of machine operations for the removal of plant growth on ditch banks. —EDITOR.

DISKING operations for canal-bank maintenance have been developed on the Imperial Irrigation District for its 2,600 miles of canal and drains to eliminate hand labor on brush control. Annual expenditures for hand-cutting brush and bamboo had reached $160,000 and were not able to control the situation, necessitating a more economic method. Results of using the heavy disk indicate a reduction of almost one-half the cost of bank maintenance and a more effective removal of brush.

Hand-cutting, which removes brush at the ground surface, permits a continuous development of the root system, accelerated by the conditions of continuous moisture. This, in turn, promotes the rapid development of regrowth, with an increased number of shoots following each successive cutting. The development of a mechanical operation to perform this brush-cutting was begun as an experiment and led to the present use of a heavy type of disk with special features to meet the unusual working conditions found on canal banks. As built in the district shop, the equipment is comparable to stock disks of ordinary type but is of heavier materials.

The disk blades (the only finished parts that are purchased) are 22 in. in diameter and $\frac{5}{16}$ in. thick, of specially treated steel. The frame is built up of $4\times\frac{5}{16}$-in. angle irons with special bracing to insure rigidity. The frame is 10 ft. wide and supports a double line of disks. The gang bolts are $1\frac{3}{4}$ in. square, and bearings are of special design to meet the working conditions. Particular features are the offset hitch, the method of opening and closing the gangs to the working angle desired, and the guard pan placed in front of the disk blades. This machine, pulled by a 60-hp. tractor, operates on top and on the inside and outside slopes of canal banks, carrying the work below the water level by means of the offset hitch.


Disking operations clear and compact bank, remove growth, break up silt berm and retard regrowth by cutting up roots.

Offset hitch permits disking inside bank below water surface.

Disking bamboo and brush growth for canal-bank maintenance.

Use of this equipment has reduced the cost of canal-bank maintenance to about one-half the hand-labor expenditure, and also leaves the bank in a more satisfactory condition. Disking the inside slopes, in addition to removing vegetation and chopping up the silt berm, leaves a desirable slope on the banks, suitable for future dredge operations. On the larger canals work of this kind can be performed with a disk, which would otherwise require the operation of a dragline. In addition, cultivation and packing of the canal banks in the operation of this equipment closes the existing gopher holes and reduces leakage to a minimum.

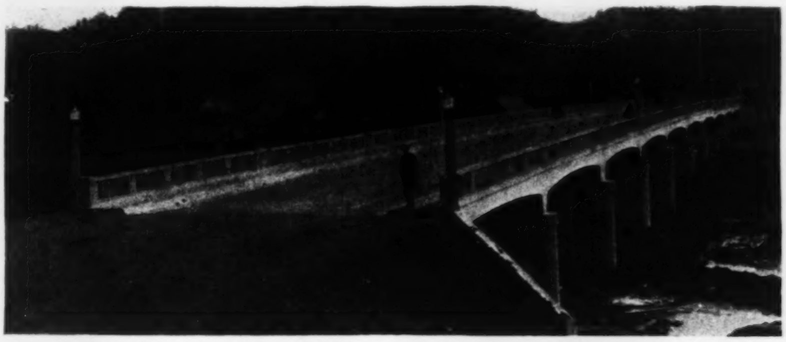
An even more important result of using this equipment is the decided tendency toward thinning out the regrowth as compared to the work of hand-cutting. After operating this equipment for a period of eighteen months it has been found that the time required for regrowth is much longer and a decided thinning of the new growth takes place after each disking. As much as 65 per cent eradication has been shown following the third disking.

The district has four of these machines in operation at the present time, and each unit completes the disking of about 25 miles of canal (both banks) per month. In general, it may be stated that the results obtained so far are very encouraging and put the district program of control work and bank maintenance on the offensive rather than on the defensive, as it was under the hand-control method. The experimental work was carried on under the supervision of W. E. Hartzog, assistant general superintendent, assisted by A. L. Graves, master mechanic.

Double Piers for Expansion in Rigid-Frame Bridge

By F. C. Hart
Resident Engineer, Arkansas Highway Department, Harrison, Ark.

IN ORDER to secure maximum waterway with minimum deck elevation, a rather unique type of reinforced-concrete bridge with rigid-frame slab deck was chosen by the Arkansas state highway department for a crossing over Crooked Creek at Harrison, Ark., in which each 38-ft. span is made to stimulate a flat arch, the slab being 17½ in. thick at the center. A particular feature of the design is the use of double elastic piers and elastic abutments to take care of temperature changes.



Rigid-frame bridge at Harrison, Ark., in which double piers and articulated abutments provide for temperature changes.

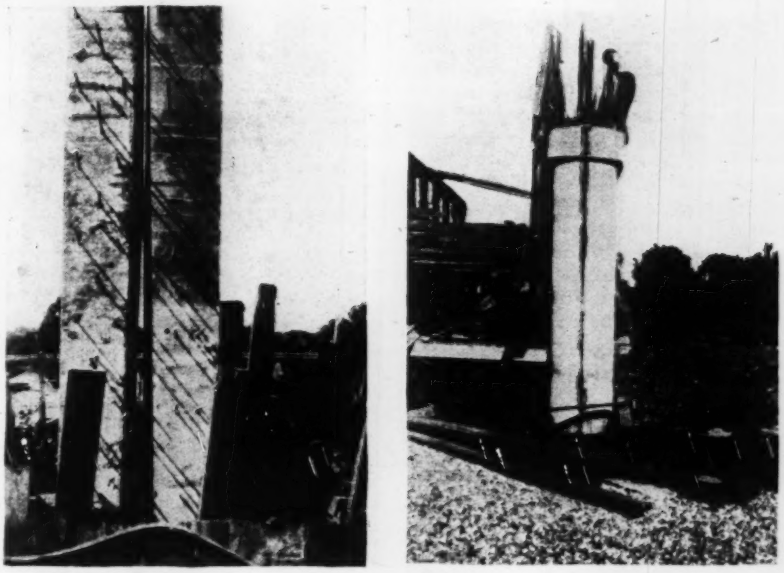
The bridge consists of ten spans and has an over-all length of 401 ft. The roadway is 30 ft. wide, and the total width of the bridge is 42½ ft. No girders are used, the deck slab being self-supporting. The bridge was designed for no settlement of the footing, and this caused a difficult problem of construction because rock was not found as anticipated. On the contrary, at an average depth of 15 ft. below streambed an underground stream of water was found running at right angles to the creek. This stream was in a very deep crevice in the limestone rock and was encountered at every footing. It was impractical to excavate to the bottom of the crevice, so excavation was carried to a depth at which the crevice narrowed from 3 ft. at one of the piers to 15 ft. at one of the abutments. The footings were then increased in thickness and designed as beams to span the crevice.

To compensate for temperature, the bridge is divided into four units, consisting of two spans, three spans, three and two spans, respectively. The breastwall of the abutment is made independent of the wingwalls but is integral with the slab. While a construction joint is placed at the springing line of each span, the reinforcing steel continues into the slab in such a way that contraction and expansion of the slab will be taken care of by movement in the breastwall. The same arrangement of reinforcing steel occurs at the piers which, at the end of each two or three-span unit, are double-elastic structures. These double piers consist of two independent sections 1 ft. apart at the bottom and 1 in. apart at the top, set on a single footing. The outer lines of the double pier are plumb, and the inner lines batter so that each section is 18 in. thick at the top and 12 in. thick at the bottom. From the top of the pier to the deck the sections are separated by 1-in. bituminous felt. The opening between these sections is closed at the ends of the pier by a semicircle of reinforced concrete of 18 in. radius separated into quadrants by a vertical piece of bituminous felt 1 in. thick. This maintains the two sections independent of one another and at the same time gives the appearance of a single pier.

In building these double piers one of the sections was formed and poured, the forms removed and a collapsible form for the inside of the second section set up against the first. This form was run up to within 5 ft. of the top, where, the space between the two sections becoming too narrow, wedge-shaped strips of seasoned oak were inserted. Reinforcing steel was then placed and the outside form set up, the whole being held together during concreting by bolts run through the entire pier. The semicircles at the ends of the double piers were then poured, and the deck constructed.

Plans for the bridge were prepared in the office of the Arkansas highway commission, of which N. B. Garver is bridge engineer. The contract was let to the Interstate Construction Co., Fort Smith, Ark., Streat Boyd, superintendent of construction. The work was completed in 133 working days. The writer was resident engineer for the highway department.

Double piers were battered on inner surfaces, as shown at the left, and were finished off at the end with semicircles divided into quadrants as shown below.



Jacketed Creosoted Piles Repel Marine Borers

Long trestle of untreated wood across Perdido Bay was attacked by Bankia and Sphaeroma borers in succession due to change in water conditions, and became unsafe soon after sale to public

By Winston E. Wheat
County Engineer, Escambia County, Pensacola, Fla.

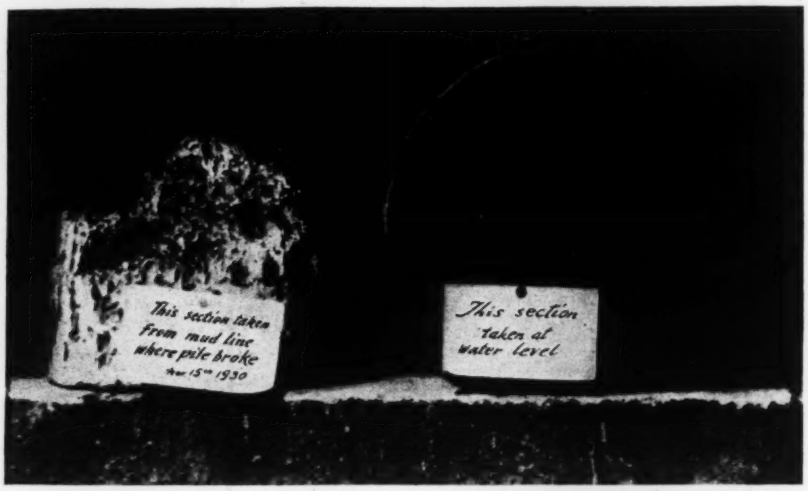
PROTECTING wood structures in sea water against attack by the various forms of marine borers is very important. Correct design is dependent upon determining which of the various forms of borers is present in the water and just how they work under the conditions existent.

Usually the *Teredo navalis* is the only marine borer given consideration. A striking illustration of the fact that the *Teredo* is not the only "bug" to be feared and that he and his fellows do not always work in a certain way is found in the failure of the substructure of an old wooden highway trestle known as Lillian Bridge, over Perdido Bay, on the Florida-Alabama boundary 12 miles west of Pensacola. What was found there will be described in this article in the hope that it may help those confronted with problems of protecting structures exposed in sea water.

The borers most feared in salt water are, usually, the *Teredo navalis, Bankia gouldi, Sphœroma* and *Limnoria*. Damage by the first two is prevented by impregnating the wood with certain preservatives, such as creosote oil. Creosote is effective against *Teredo* and *Bankia* unless one of the other borers is present to open the way through the outer fibers impregnated with the oil. Where the *Sphœroma* or *Limnoria* are present some designers incase creosoted piling in cast-iron, concrete or vitrified clay pipe for protection, placing the pipe along that portion of the pile that experience has shown likely to be attacked.

The more or less experienced man will generally state that the most active attack of marine borers is found at or near the tide level. But if the designer depends on these bugs "running true to form" he may regret his confidence.

Lillian Bridge was an untreated wood pile trestle about 4,800 ft. long, built as a highway toll bridge over Perdido Bay in 1916. The bay averages 8 to 12 ft. deep, with mud bottom. In 1926 by well-directed publicity, interested parties managed to arouse the citizens of Pensacola, of Escambia County, Fla., and of South Baldwin County, Ala., to demand that the bridge be purchased and operated by the two counties jointly as a toll-free bridge. As a result it was purchased, although against engineering advice at the time, and was operated continuously by the two counties until, on Dec. 17, 1929, it was closed to traffic after four crashes in one year (fortunately none fatal) demonstrated the danger to human life involved in continued use of the structure.


This section taken from mud line where pile broke Nov 15th 1930
This section taken at water level

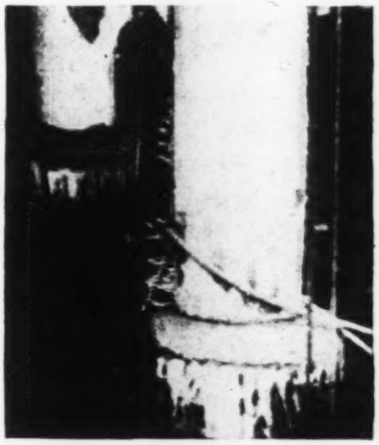
Sections of old bridge piling taken from mud line (left) and waterline (right) showing how marine borers concentrated their activities at mud line.

At the time the bridge was taken over by the counties the principal defects evident were above tide. Piling had rotted above water level, and this was cared for by cutting off at low water, putting on a false "cap" and erecting well X-braced columns above. This, with constant replacement of rotted caps, stringers and flooring, kept the bridge in operation. Piles cut off at low water showed practically no harm done by marine borers, which was accounted for by the theory that frequent floods of fresh water from the Perdido River and other streams kept the salinity of the bay water during the greater part of the time below that favorable to these borers. It was generally assumed that the piles were in good condition from water level down. However, in January, 1929, a loaded bus caused one pile bent to fall out, and investigation showed that the old piles which had been sawed off at tide level and used as foundation for the columns above had broken off at the mud line, 10 ft. below tide level. With the help of Lieut. Commander William Angas, public-works officer at the U. S. Naval Air Station, Pensacola, the writer made an examination of other piles in the structure, and found that while they were in practically perfect condition at tide level they were badly eaten away below water. After another crash occurred, again demonstrating the danger of longer ignoring the condition, the bridge was closed for several weeks and two new piles placed in each bent. The structure was reopened to traffic, but plans for a new bridge were started. The design fell to the lot of the writer as engineer for Escambia County, when the commissioners of the two counties agreed to have the Florida county finance the structure as a county-owned toll bridge.

A traffic survey indicated that the investment should be limited to about $200,000. Borings showed that under the 10 or 12 ft. of water lay a stratum of extremely soft mud, as much as 22 ft. in thickness, below which lay a formation consisting of various strata of sand and mud; so it was evident that long piles would be required. A study soon indicated that the cost of concrete piles would be prohibitive. The investigation of the causes responsible for the failure of the old bridge having revealed the presence of a species of marine borer not stopped by creosote, it was finally decided to use a heavily creosoted timber pile and to incase this in a jacket of concrete from a point 3 ft. below mud line to 2 ft. above tide level. This substructure, with a reinforced-concrete slab deck, has recently been completed, the contract price running about $40 per linear foot of bridge, complete.

Careful examination of the old bridge showed the "pallets," hair-like antennæ of the borer, protruding from holes in the surface of the piles in the water. But real light was shed on the trouble when one of the old piles was recovered after the second collapse. As before, this failure was at the mud line, 10 ft. below tide level. Of the 12-in. pile there remained not over 2 in. of good wood at the point of failure, the rest of the cross-section being literally honey-combed; 3 ft. above the mud line there was not much damage. The pile showed evidence of having been attacked not only by a worm of the molluscan veriety but also by a bug of the crustacæ. The first named was identified as the *Bankia gouldi*, the second as *Sphæroma destructor*. The printed report of the committee of the National Research Council on investigation of marine borers by Atwood and Kent (1928) proved of great value in our study. One of the piles from the old bridge was sent to Prof. William F. Clapp, of Boston, a member of the committee mentioned, and he wrote a most interesting letter (Jan. 3, 1930), the essential parts of which are:

> A large portion of the damage has been caused by *Bankia gouldi*, during the late spring or summer or early fall of 1928. These *Bankia* were later killed by fresh water and the animal matter was devoured by carnivorous worms. The *Sphæroma* then entered the wood and continued the destruction. A slight attack by *Bankia gouldi* also came during this year, probably late in the summer.
>
> That the attack was comparatively recent is shown by the fact that nearly all of the large *Bankia* tubes contain the shells of that species in good condition. They disintegrate and disappear quite quickly. This heavy attack lasted for several months, for the tubes are large and the growth was rapid and healthy. A large part of the attack took place last year. If it had been during 1927 the remains of the shells would have been in much worse condition. If it had happened in 1929 more tubes would contain remains of the animal matter and pallets, for the worms could not have cleaned the tubes out in so short a time. The pallets are nearly all gone or are pushed up into the middle of the tube, characteristic of the work of the scavenger worms. The few *Bankia* which entered the wood during 1929 did not thrive. They were all small but still alive when the wood was removed from the water. That the conditions were unfavorable is shown by the large number of *Modiola* and *Lithophaga* (harmless brackish water bivalves) which had taken possession of many of the emptied *Bankia* tubes. *Sphæroma* are more apt to be plentiful where this species of *Modiola* lives than *Bankia* or *Teredo* are. There were still many specimens of *Sphæroma* in the wood, but 80 or 90 per cent of the damage was caused by *Bankia gouldi*.
>
> In reply to the question in your last letter: *Sphæroma* does attack creosoted wood more readily than either *Bankia* or *Teredo* or the other destructive crustacean, *Limnoria*, exposing the unprotected wood to the latter attack of the shipworms. On the other hand, the two do not live together. Brackish to almost fresh water, which supports *Sphæroma*, is fatal to the shipworm, and a salinity which is favorable to shipworm activity will not support *Sphæroma*.



Piling on new bridge was incased in concrete shell from above water line to below line of probable scour. Ropes shown are supporting metal form until concrete has set.

To be sure that the incasement of the new bridge piles was being carried sufficiently deep for protection, one of the piles from the old bridge was pulled up. It was found that while the pile was completely riddled at the mud line, the wood was in perfect condition below that point. And, as before, very little damage had been done at tide level.

Four different forms of life were found in this pile, and specimens were sent with samples of water to Prof. Clapp, who responded (March 18, 1931) as follows:

> I have examined the water samples and find that the salinity of the surface sample is 1.007 and of the bottom sample 1.0158. The latter salinity is sufficiently high for *Bankia gouldi* to thrive in if other conditions (food supply, temperature, etc.) are favorable. This species can exist in salinity as low as 1.007, as I proved by finding large specimens in wood from a bridge in South Carolina where the water for a long period of time had a constant salinity of from 1.006 to 1.008.
>
> The specimens sent to me are as follows: The shipworms are *B. gouldi*, fine, healthy specimens. The destructive crustacea are two specimens of *Sphæroma destructor*. Creosoted piling is not immune from attack by this organism. I have sections of many heavily treated timbers entirely destroyed by *S. destructor*.
>
> The shrimp-like crustacea are *Amphipods*. They are so delicate that they have gone to pieces, but from the fragments I am convinced that they are not the destructive *Chelura*. The other worms are scavengers, *Pterochates*, which clear out the burrows of dead teredos but do no damage themselves.
>
> The method you are using to protect your piling will make attack by any of the above organisms impossible, as long as no large breaks occur in your cement casing. When that happens (it will have to be more than a narrow crack) *Sphæroma* may get busy and in time open up untreated wood to the attack of *Bankia*.

Various theories have been advanced to explain the activity of the borers being concentrated at mud line on this bridge. In the view of the writer the condition of the water is most favorable at that point. Thus while the salinity of the upper strata of water in Perdido Bay is frequently lowered by being flooded with fresh water from the Perdido and Styx rivers, and a very restricted opening into the Gulf of Mexico makes the restoration of full salinity by tidal flow a slow process, the water at mud line is kept fairly salty by contact with the deep underlying mud which is impregnated with salt. Lillian Bridge is subjected alternately to brackish and salt water. As suggested in Prof. Clapp's first report, there were some seasons in the life of the old bridge when one type of borer thrived, and other years when another variety did its work. In the writer's opinion, should the weather conditions have kept the salinity and other elements fairly constant for very long at a time the damage would have been several times greater. In near-by Pensacola Bay another dangerous salt water borer, the *Limnoria*, has been reported by some observers. Should a long drought result in high salinity in Perdido Bay for a considerable time, it seems probable that *Limnoria* would get to work there, too. Like *Sphæroma destructor*, the *Limnoria* is known for his immunity to creosote.

Incasement of timber piling in concrete or in vitrified clay or cast-iron pipe filled with sand or concrete has been successful in a great number of installations. With the clay pipe, care to protect it from breakage is very essential; boats, drift or excessive vibration endanger it. With any type, care must be taken to carry the incasement below probable depth of scour. A number of different methods of incasement are reviewed in a most constructive way in the report of the committee on marine borers (Atwood and Kent) referred to above. Anyone interested in the subject would do well to secure and read that report.

The method of incasing the piling on new Lillian Bridge, arrived at after considerable experimenting, assures a shell of concrete not less than 4 in. in thickness, reinforced with galvanized steel mesh and poured in a sectional form of sheet metal, painted inside and outside with tar. This form was made up in short sections, the lower one being of special design to prevent the concrete falling out. The form was lowered as the concrete was placed, additional sections being put on and filled until the desired length of incasement was secured. Not less than 3 ft. below mud line on each pile was required on this structure. The method used is also well adapted to salvaging existing pile structures that have been attacked by marine borers.

Royce Kershaw, Inc., Mobile, Ala., was contractor for the Lillian Bridge and F. L. Jennings was resident engineer in charge of construction.

Stability of Dams Increased by More Economical Use of Materials

Progressive changes from solid gravity dam to buttress type show increasing stability with a decrease of indeterminate factors

By Calvin V. Davis
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THE SAFETY FACTORS in a gravity dam may be materially improved by the inclusion of large cellular spaces and the redistribution of the material that otherwise would have filled those spaces. If, for example, the material from these cellular spaces is so distributed as to give an inclined upstream face that introduces the stabilizing effect of a large vertical water load, the safety factors in the redesigned structure will be nearly double those obtained with the conventional gravity design and will be comparable with safety factors used for other important engineering structures. Costs, on the other hand, in such a design are increased by an increase in the amount of formwork. Indeterminate factors such as the extent of uplift are little affected by this change. However, continuing the redistribution of the material to the point where the structure becomes a series of massive buttresses connected by arches or slabs makes it possible to reduce the amount of material without loss of strength and with certain improvement in safety factors, such as the reduction of uplift. Carrying the reduction and redistribution of material still further brings us to the familiar slab-and-thin-buttress type of dam, a much less expensive dam than a gravity dam, and, within certain limits, less costly than the massive-buttress type, yet one in which fewer indeterminate factors are found than are found in the gravity dam. Analysis of these general types will show that each has features to commend it for meeting special requirements as to location, foundation conditions or cost.

Comparison of types

These statements may be illustrated by a comparison of the structural and economic characteristics of a conventional gravity-type dam (Fig. 1) and the modified dam, which will hereafter be termed the massive-buttress-type dam (Fig. 2). These designs, each of which is for dam of a height set arbitrarily at 150 ft. for comparative purposes, were prepared with a view to obtaining structures of equal costs.

The gravity dam selected for comparative purposes (Fig. 1) is a typical conservative design of this type. The ratio of base width to height of 0.8, a value now in common use, gives an approximately tri-angular foundation-pressure diagram. Uplift pressure is assumed to vary uniformly from 75 per cent of the full static head at the heel to zero at the toe. The sliding factor of 0.75 at maximum height would be satisfactory for a sound rock foundation.

The coring out of masonry in the gravity dam, as illustrated by Fig. 2, creates in effect a series of massive buttresses between which are relatively wide cellular spaces. These open spaces effectively drain all parts of the structures and practically eliminate uplift pressures under the massive buttresses. Lateral drains through the buttresses will provide outlet for any small amount of seepage that might come through the joints.

The spaces between the buttresses of the design shown in Fig. 2 are spanned upstream by thick circular arch barrels that are designed for a maximum compressive stress of 300 lb. per sq.in. An alternate type of water-bearing member that may be used in connection with the cellular-gravity-type dam also is shown.

In preparing the structural analysis for the massive-buttress dam shown in Fig. 2 it was considered that the arches and the buttresses would act together under load as a single monolithic structure, and that the arches would take normal pressures on horizontal planes as well as the stresses induced by normal water loading on their upstream faces. For comparative purposes the downstream slope of the buttresses was kept the same as that of the gravity dam. The upstream slope was flattened an amount sufficient to give approximately uniform foundation pressures not greater than the maximum of the gravity design.

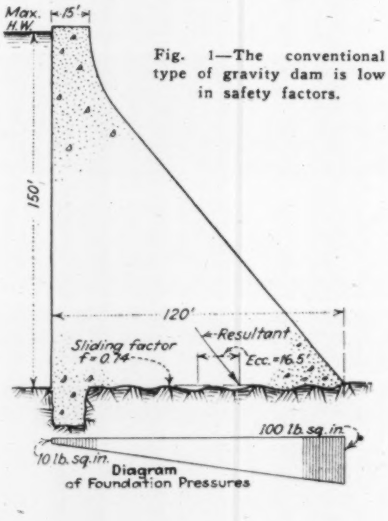


Fig. 1—The conventional type of gravity dam is low in safety factors.

On the basis of equal costs of the designs illustrated by Figs. 1 and 2, the volume of the massive-buttress type dam at the assumed height of 150 ft. is about 15 per cent less than that of the gravity dam. This difference was purposely maintained in making the design studies to offset the increased cost of the more difficult arch construction required for the massive-buttress design.

The structural safety of the massive-buttress-type dam is, of course, dependent on the structural safety of its component parts, the water-bearing member and the buttress. Both of these must be considered if the factors of safety are to be compared with those of the gravity type dam.

Combined arch and brace overcomes objectionable features

The circular-arch barrel (Fig. 2) has a high degree of structural safety owing to its thickness, its large central angle (160 deg.), which minimizes lateral thrust, and its low unit stresses, which are entirely in compression. The use of this type of deck, however, might be objectionable in a district subject to earthquake shocks or where the foundation conditions were such that the use of heavy lateral bracing would be advisable.

In order to provide a type of water-bearing member suitable for construction in any location, an alternate design is shown (Fig. 2), which offers a high degree of safety under earthquake conditions, or where there is danger of severe lateral loads being imposed on the buttresses.

The water-bearing member consists of two arched members directly in contact along a painted asphalt joint between the intradosal surface of the upstream arch and the extradosal surface of the downstream arch. The water-bearing face of the upstream arch is kept in the plane of the upstream buttress faces, giving in effect a structural member that is capable of acting either as a brace or an arch. If lateral forces such as might occur during an earthquake are imposed on the buttresses, the water-bearing member will be capable of acting as a brace between the buttresses. Under normal conditions it will take part of the loading in arch action.

A very conservative design would be obtained if the upstream and downstream arches were each proportioned to take the entire water load but the upstream members were depended upon for bracing effect only. An additional advantage of this arrangement would be the protection it would afford to the downstream arch from any possible disintegrating effect of contact with the water in the reservoir.

The type of water-bearing member used in connection with the massive-buttress dam is, however, incidental to the main principle involved, which is to increase the structural safety of dams through the use of massive buttresses rather than a single monolith, such as is obtained in the ordinary gravity design.

The increased safety of this massive-buttress design over that of the standard gravity design may best be shown by a comparison of the structural characteristics and safety factors of the two dams of 150-ft. height. This comparison (Table I) shows conclusively that the material in a gravity dam is used to the least advantages from the viewpoint of obtaining structural safety. On the other hand, the scientific distribution of a smaller amount of material in the massive-buttress dam gives factors of safety against sliding and overturning, which are respectively 1.52 and 2.27 times greater than those of the gravity design. The value of the maximum pressure for both designs is so low that no problem of concrete strength is involved. The lowest factor of safety in compression, about 8, is obtained in the arch.

TABLE I — COMPARISON OF STRUCTURAL CHARACTERISTICS AND SAFETY FACTORS FOR HEIGHT OF 150 FT.

Characteristic	Standard Gravity Type	Massive-Buttress Type
Uplift..............	Assumed to vary from 75% of full static head at heel to zero at toe	No uplift
Form of foundation-pressure diagram..	Triangular	Nearly uniform
Maximum foundation pressure, lb. per sq.in............	100	100
Eccentricity, ft......	16.5	2.5
Sliding factor (*f*)....	.740	.485
Factor of safety against overturning	2.20	5.00
Cost..............	Same for both structures	

Advantages of wider buttress spacing

Further economic advantages incidental to mass concrete construction, without sacrifice of the high safety factors that characterize the buttress dam, may be obtained in an improved design having a relatively wide buttress spacing and thick masonry sections. Comparative estimates show that between certain limits the cost of this improved structure will not be greater than the cost of the conventional buttress dam having relatively close buttress spacing and thin masonry sections. To demonstrate this, four dams of equal height were analyzed for comparative purposes. These consisted of a standard gravity design, two modifications of the massive-buttress design previously considered, and a thin-buttress design such as that of the Stony Gorge dam recently constructed by the Bureau of Reclamation or that of the Powder River dam now being built by the bureau (*E.N.-R.*, Oct. 15, 1931, p. 634).

It is important to note that the principles developed in this paper are not limited to the heights to which these comparative designs were carried, as the writer has found that they apply with even greater force to buttress dams with heights ranging up to 500 ft. or more.

The first of the modified massive-buttress type dams (Fig. 3) has both the upstream and downstream faces sloped six horizontally to ten vertically. These proportions were selected because they gave an almost ideal stress distribution —that is, approximately uniform foundation pressures and a uniform distribution of first principal or maximum inclined stress. Of particular importance is the uniform foundation-pressure distribution, which increases the safety of the structure through minimizing unequal settlement if poor foundations are encountered. The relation of the stress functions for two typical governing points, *A* and *B*, are shown by the Mohr's circle plotted for these points.

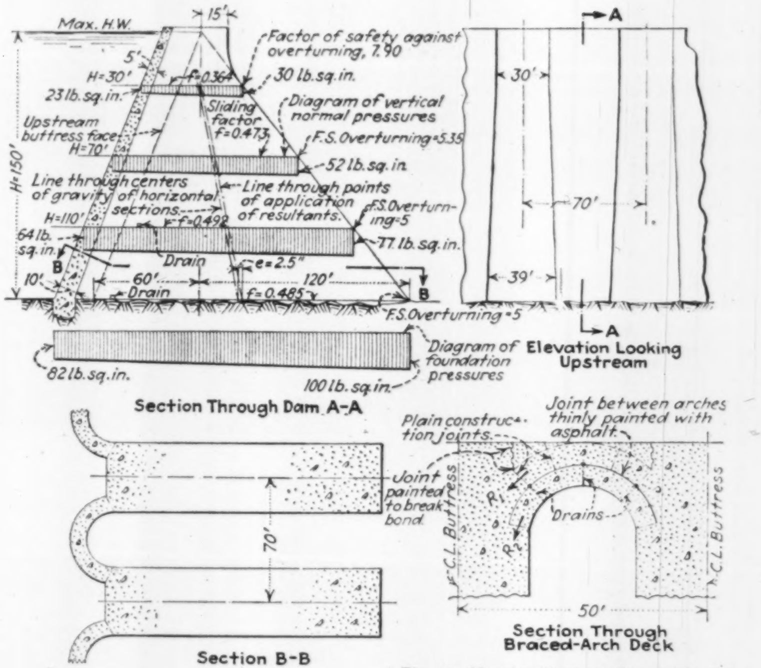

Max. H.W.
15'
5'
H=30'
f=0.364
23 lb. sq. in.
Factor of safety against overturning, 7.90
30 lb. sq. in.
Diagram of vertical normal pressures
Upstream buttress face
Sliding factor f=0.473
H=70'
F.S. Overturning=5.35
52 lb. sq. in.
H=150'
Line through centers of gravity of horizontal sections
Line through points of application of resultants.
H=110'
f=0.492
F.S. Overturning=5
64 lb. sq. in.
77 lb. sq. in.
B
Drain
e=2.5"
10'
60'
120'
Drain
f=0.485
B
F.S. Overturning=5
Diagram of foundation pressures
82 lb. sq. in.
100 lb. sq. in.
Section Through Dam A-A
A
30'
70'
39'
A
Elevation Looking Upstream
70'
Section B-B
Plain construction joints
Joint between arches thinly painted with asphalt
Joint painted to break bond
C.L. Buttress
R1
R2
Drains
C.L. Buttress
50'
Section Through Braced-Arch Deck

Fig. 2—Massive-buttress dam with concrete quantities equal to gravity dam of similar height.

The water-bearing member, or deck, for the massive-buttress-type dam may be of any of the conventional types. The most common of these are the arch, the Ambursen flat-slab and haunch type, or the round-head buttress type recently originated by Fred A. Noetzli, of Los Angeles. The Ambursen deck was selected for the design used as a basis of this discussion, although there is little to choose between this type and the alternate round-head design.

A modified flat-slab design having structural characteristics similar to those of the braced-arch design is shown by Fig. 3. Both flat-slab designs have high earthquake-resisting properties, as each design combines flexibility with great structural strength for the dam as a whole. The combination of two slabs in contact makes possible a better distribution of loading on the bearing surfaces of the buttress and gives a large reserve of resistance to lateral thrust such as might be imposed during earthquake conditions. The cost of either the flat slab or the round-head type would be about the same at a height of 150 ft.

The buttress thicknesses of the second of the modified massive-buttress dam studied are 2 ft. less at the crest and 3 ft. less at the foundation than those shown in Fig. 3. These decreased thicknesses had little effect on the safety factors of the structure other than slightly to increase the first principal stress in compression and the vertical normal pressures. The values of both of these stress functions are exceedingly low, and the safety factors for stress are much higher than those for both

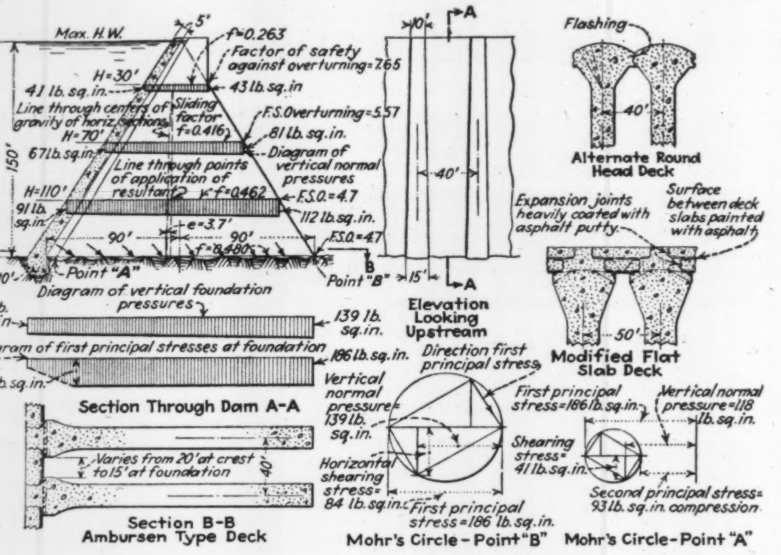

Max. H.W.
5'
f=0.263
Factor of safety against overturning=7.65
H=30'
41 lb. sq. in.
43 lb. sq. in
Line through centers of gravity of horiz. sections
Sliding factor f=0.416
F.S. Overturning=5.57
H=70'
81 lb. sq. in.
67 lb. sq. in.
Diagram of vertical normal pressures
Line through points of application of resultant
f=0.462
150'
H=110'
F.S.O.=4.7
91 lb. sq. in.
112 lb. sq. in.
e=3.7'
90'
90'
F.S.O.=4.7
f=0.480
B
10'
Point "A"
Point "B"
B
Diagram of vertical foundation pressures
114 lb. sq. in
139 lb. sq. in.
Diagram of first principal stresses at foundation
186 lb. sq. in.
186 lb. sq. in.
Section Through Dam A-A
Varies from 20' at crest to 15' at foundation
40'
Section B-B
Ambursen Type Deck
10'
A
40'
15'
A
Elevation Looking Upstream
Flashing
40'
Alternate Round Head Deck
Expansion joints heavily coated with asphalt putty
Surface between deck slabs painted with asphalt
50'
Modified Flat Slab Deck
Direction first principal stress
Vertical normal pressure= 139 lb. sq. in.
Horizontal shearing stress= 84 lb. sq. in.
First principal stress=186 lb. sq. in.
Mohr's Circle - Point "B"
First principal stress=186 lb. sq. in.
Vertical normal pressure=118 lb. sq. in.
Shearing stress= 41 lb. sq. in.
Second principal stress= 93 lb. sq. in. compression
Mohr's Circle - Point "A"

Fig. 3—Modified massive-buttress dam. This design has advantages over that shown in Fig. 2.

sliding and overturning, which are approximately the same for both designs.

In preparing the latter design the deck spans were kept the same as those used in the former. In order to retain the same bending span the bearing surface of the haunch under the slab, 5 ft. wide, was kept the same for both designs. Also, the upstream portion of the buttress adjacent to and in contact with the slab was made somewhat thicker than the downstream portion of the buttress. The writer has found that this type of water-bearing member—that is, a slab with a comparatively short span supported between two flared, massive-buttress sections—offers possibilities for obtaining an unusually economical design. The wide buttress spacing allowed by this arrangement both decreases form cost and permits the use of thick buttress sections. This, in turn, decreases the cost of placing concrete and also, in the writer's opinion, permits the elimination of buttress steel.

As the conjugate stresses for both buttress designs have relatively high values in compression, no inclined buttress steel is required. The writer submits that horizontal temperature steel in buttresses of these proportions would not be required if proper construction methods and a correct layout of buttress joints were used. The same care in construction and the laying out of joints is, of course, required in the building of a gravity dam. In this respect the buttress type of dam has two great advantages; first, the setting temperature of the concrete is lowered by the greater surface of the structure in contact with the atmosphere; and second, both the efficiency and functioning of the joints may be determined by inspection after the dam is constructed. It is purely a matter of guess in constructing a gravity dam as to what stresses are induced by the setting temperatures of the concrete and as to whether cracks, such as were revealed by the St. Francis failure, have formed within the structure.

The Reclamation Bureau design (Fig. 4.), which is a typical Ambursen dam, was constructed to a maximum height of about 140 ft. For comparative purposes, however, this design was extended to a height of 150 ft., using the same safety factors as were found at a height of 120 ft., the maximum height of design shown by the official plans. Both horizontal steel and lateral bracing are desirable for a structure of these proportions. This design was without question the most advanced of its type at the time the dam was constructed. The stresses are low, and the safety factors have satisfactory values.

Comparison of structural characteristics

Table II clearly shows the contrast between the low safety factors of the gravity dam, which depends for stability on the weight of masonry alone, and the high safety factors of the buttress dam, which utilizes the stabilizing effect of a large vertical water load on an inclined upstream face.

Comparison of economic characteristics

Comparative concrete-quantity curves (Fig. 5) indicate the relative volumes of the four designs. The volume of concrete in the Reclamation Bureau design is only 37 per cent of that in the gravity dam for a height of 150 ft. The modified massive-buttress designs are intermediate in volume to the thin-buttress and the gravity designs.

Volume of concrete per linear foot of dam is not a true index of relative cost, however, as the cost of forms and

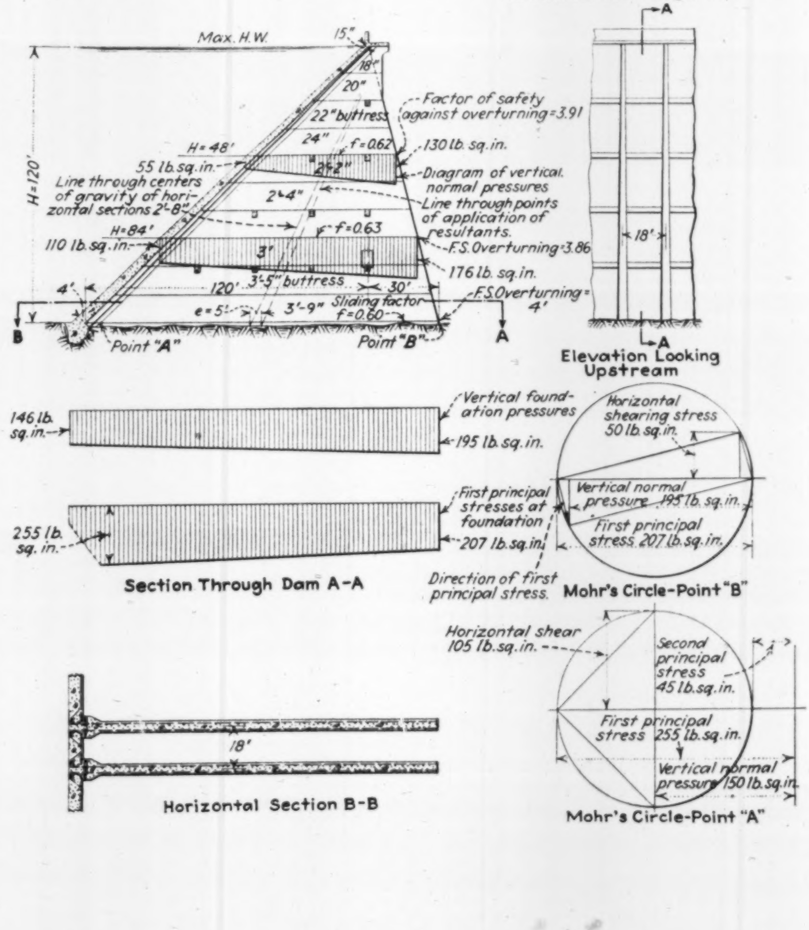

Max. H.W.
15"
18"
20"
22" buttress
24"
Factor of safety against overturning=3.91
f=0.62
130 lb. sq. in.
H=48'
55 lb. sq. in.
2'-2"
Diagram of vertical normal pressures
H=120'
Line through centers of gravity of horizontal sections 2'-8"
2'-4"
Line through points of application of resultants.
f=0.63
H=84'
110 lb. sq. in.
3'
F.S. Overturning=3.86
176 lb. sq. in.
4'
120'
3'-5" buttress
30'
F.S. Overturning= 4'
e=5'
3'-9"
Sliding factor f=0.60
B
Point "A"
Point "B"
A
A
18'
A
Elevation Looking Upstream
146 lb. sq. in.
Vertical foundation pressures
195 lb. sq. in.
255 lb. sq. in.
First principal stresses at foundation
207 lb. sq. in.
Section Through Dam A-A
Direction of first principal stress.
Horizontal shearing stress 50 lb. sq. in.
Vertical normal pressure 195 lb. sq. in.
First principal stress 207 lb. sq. in.
Mohr's Circle-Point "B"
Horizontal shear 105 lb. sq. in.
Second principal stress 45 lb. sq. in.
First principal stress 255 lb. sq. in.
Vertical normal pressure 150 lb. sq. in.
Mohr's Circle-Point "A"
18'
Horizontal Section B-B

Fig. 4—Thin-buttress dam of Stony Gorge type. It is typical of current practice in buttress-dam design.

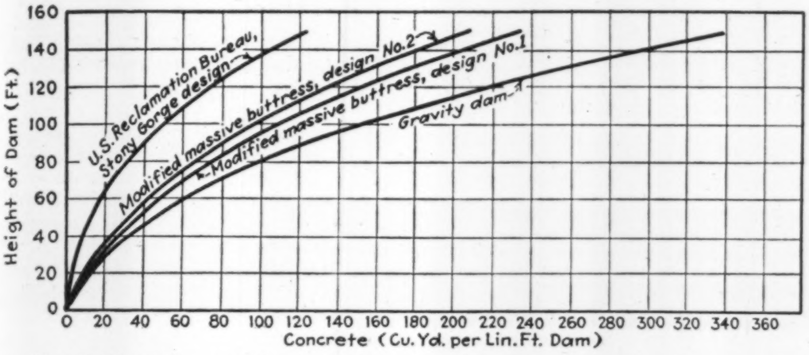


Fig. 5—Comparative amounts of concrete in four types of dams.

steel per linear foot of dam has an important influence on the cost of the structure as a whole, even though partly offset by the reduced amount of excavation required. Fig. 6 shows the comparative-cost curves, which take into account both the elements of forms and steel. In arriving at the value for these curves, the cost for all was expressed in terms of a common unit C, which represents the cost per cubic yard of concrete for the gravity and the massive-buttress designs. In determining the cost units the following mixes were assumed on the basis that the average cost per cubic yard of concrete in the Reclamation Bureau design is 1.15C:

Deck slab of Reclamation Bureau design	1:2 :4
Buttresses of Reclamation Bureau design	1:2½:5
All concrete in both massive buttress and gravity designs	1:3 :6

The following units were assumed for the cost of steel and forms:

0.50C = cost per 100 lb. of steel for all buttress designs
2.00C = cost per 100 sq.ft. of forms for gravity dam and massive-buttress designs.
2.50C = cost per 100 sq.ft. of forms for Reclamation Bureau design.

These units are consistent with present construction costs. All elements of cost for each height may be expressed in terms of a variable factor K, which when multiplied by C will give the total cost per linear foot of dam. In Fig. 6 these values of K are plotted against height for each type of dam.

Fig. 6 illustrates two rather interesting points: (1) that the cost of the modified massive-buttress (design No. 2) is no greater than that of the Stony Gorge design at a height of 150 ft., even though for this height the massive-buttress design has a substantially larger volume of concrete; and (2) the tendency of increased steel and form areas to equalize the cost of construction. It will be noted how much closer the comparative-cost curves are than the comparative-concrete curves. Table III shows the cost for each design for a maximum height of 150 ft., expressed as a percentage of the cost of the gravity dam.

The comparison of the structural characteristics (Table II) and the cost curves (Fig. 6) for the several designs discussed in this paper clearly and forcibly point to three conclusions: (1) that the gravity dam offers the lowest safety factors for both the highest cost and for the largest volume of material; (2) that the thin-buttress dam offers the highest safety factors for both the lowest cost and for the minimum volume of material; and (3) that there is an intermediate massive-buttress type that retains both the economy and the safety factors of the thin-buttress dam and the advantages incidental to the use of economical mass concrete.

TABLE II — COMPARISON OF STRUCTURAL CHARACTERISTICS AT FOUNDATION LINE FOR HEIGHT OF 150 FT.

	Type of Dam			
Characteristic	Gravity	Massive-buttress design No. 1	Massive-buttress design No. 2	Reclamation Bureau design Ambursen thin buttress type
Uplift	Assumed to vary from 75% of full static head at heel to zero at toe	No uplift	No uplift	No uplift
Form of foundation-pressure diagram	Triangular	Nearly uniform	Nearly uniform	Nearly uniform
Maximum foundation pressure, lb. per sq.in.	100	139	166	195
Max. value of first principal stress and location, lb. per sq. in.	164 at downstream toe	186, uniform	230, uniform	255 under haunch
Eccentricity, ft.	16.5	3.7	6.7	5
Sliding factor(f)	.740	.480	.522	.60
Factor of safety against overturning	2.2	4.7	4.34	4.00

TABLE III — COST OF DAM, 150 FT. HIGH, EXPRESSED AS PERCENTAGE OF COST OF GRAVITY DAM

Type	Per Cent of Cost of Gravity Dam
Gravity	100
Massive-buttress design No. 1	75
Massive-buttress design No. 2	68.7
Reclamation	68.7

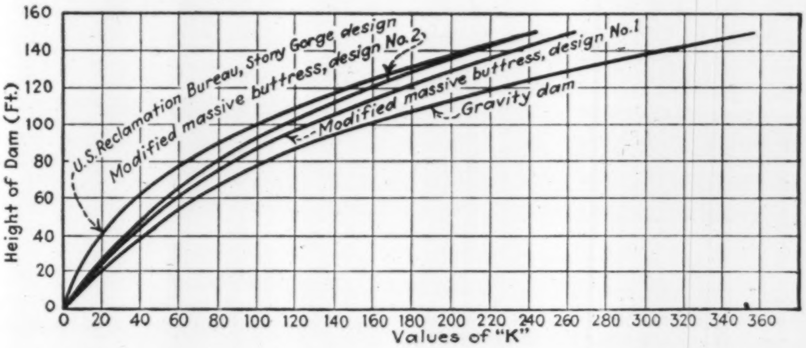


Fig. 6—Comparative costs of four types of dams.

The first conclusion is in line with the fact that many engineers have long recognized that the gravity dam, as designed and constructed under present practices, has lower safety factors than are tolerated in any other class of engineering structures. Many engineers insist that the safety factors indicated by the present methods of designing gravity dams are only apparent and that the real margin of safety is even lower than design computations now indicate. These opinions have been in part substantiated by recent mathematical investigations carried out by several engineers in this country and abroad. This research has illustrated that tension may exist in a gravity section that appeared to be entirely in compression when analyzed by the law of the trapezoid. In the writer's opinion, these investigations will have a far-reaching effect on concrete-dam design. A possible effect of this research is that even greater base widths than are now used under present practices may be required for gravity dams. The result of this trend may be that the use of gravity dams will be economically unfeasible for many hydraulic projects if the steadily increasing demand for higher safety factors is to be met.

Furthermore, the present general practice of using a greater number of construction joints in a gravity dam to minimize the uncertain internal stresses is an important factor in gravity-dam design, which both increases the cost of construction and complicates design procedure. An outstanding example of this accepted practice is the design for the Hoover Dam.

The second and third conclusions suggest the obvious solution of the problem of obtaining both increased safety and economy of construction through the elimination of the surpluses of useless material of the conventional gravity dam by coring out of the massive section. This procedure logically causes the gravity section to evolve to the buttress-type dam, with the gratifying result that the improved designs thus obtained have safety factors that are comparable with safety factors used for other important engineering structures.

* * *

New Form of Dam Proposed for Narrow Rock Canyons

Thrust-buttress type, developed for a Mexican site requiring a high dam, is proof against overtuning, sliding and uplift effects and is 40 to 60 per cent smaller than a gravity structure

By C. H. Howell

Chief Engineer, The J. G. White Engineering Corp., S. en C., Mexico, D.F.

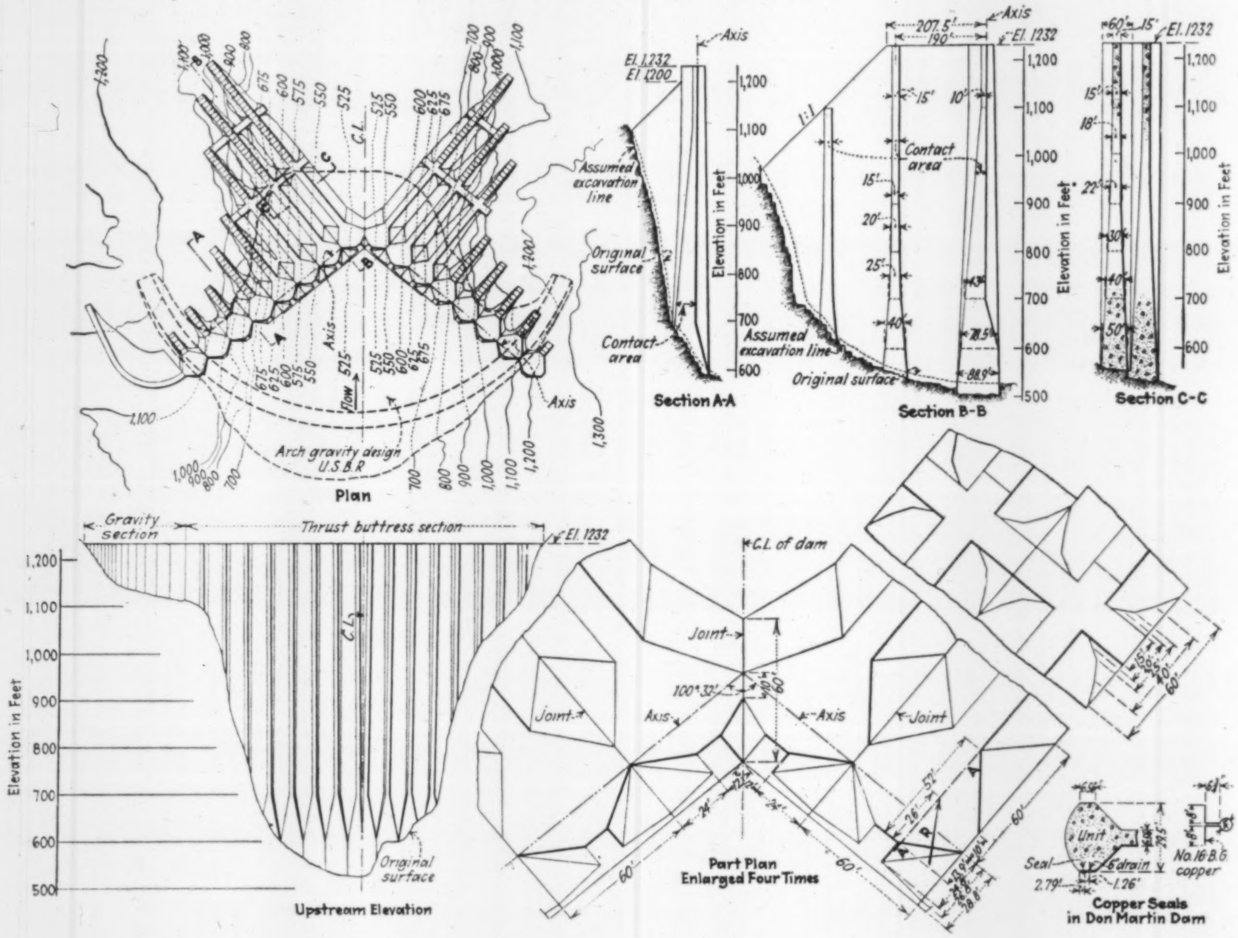
A DAM in which the water pressure is transmitted direct to the abutments by thrust walls or buttresses instead of to the valley bottom can neither overturn nor slide. In a suitable design based on this principle the effect of uplift is nullified. Temperature and volume changes of the concrete do not affect the maximum stresses and, with the assumption of unyielding abutments, the concrete stresses are determinate and not excessive. No tensile stresses occur. Finally, the dam is economical.

The new type, called the thrust-buttress dam, is suited only to narrow canyons with sound rock abutments. It contains from 40 to 60 per cent of the concrete required for a gravity dam. The saving in riverbed excavation and concrete volume below riverbed will generally be even greater, and construction contingencies will therefore be reduced. Partly offsetting these advantages, the thrust-buttress dam will require somewhat more abutment excavation.

Compared with an arch dam the thrust-buttress dam will probably show a saving only at sites exceptionally favorable for the thrust buttress. The analysis of an arch dam is, however, as complicated a problem as any that designers have to consider. There are many at this time who would hesitate to use a thin arch design for exceptional heights such as 400 to 700 ft. because of the inherent difficulties and uncertainties of the analysis. It is in such conditions that the thrust-buttress design may afford a satisfactory solution to the problem.

In the writer's opinion, it can be analyzed more definitely than an arch

Fig. 1—By transferring the water load direct to the rock walls of the canyon, the thrust-buttress form of dam avoids all overturning, sliding and uplift hazards. It is here shown as it would appear if applied to the site of the Hoover Dam. It saves about half the volume of concrete.


Plan
Axis
C.L.
Flow
Arch gravity design U.S.B.R.
1,100
1,200
1,300
A
B
C
Section A-A
El. 1,232
El. 1,200
Assumed excavation line
Original surface
Contact area
Elevation in Feet
Section B-B
207.5'
190'
Axis
El. 1232
1:1
15'
10'
20'
25'
40'
78.5'
88.9'
Contact area
Assumed excavation line
Original surface
Section C-C
60'
15'
18'
22'
30'
40'
50'
Upstream Elevation
Gravity section
Thrust buttress section
C.L.
Original surface
C.L. of dam
Joint
100°32'
Axis
Part Plan Enlarged Four Times
24'
26'
52'
60'
Copper Seals in Don Martin Dam
Unit
Seal
6" drain
2.79'
1.26'
29.5'
No. 16 B.G. copper

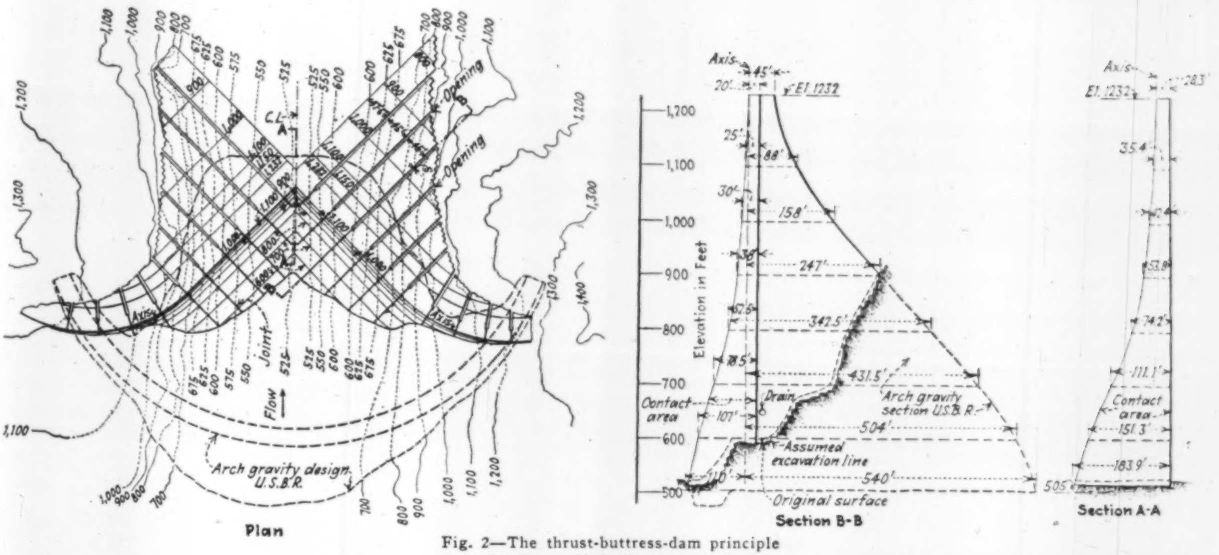


Fig. 2—The thrust-buttress-dam principle may also be applied advantageously to a gravity design. Such a design, adapted to the Hoover Dam site, is here shown.

or a gravity dam in a narrow canyon. It is more economical than a gravity section. The compressive stresses will compare favorably with those of the other types. It is mechanically impossible for the thrust buttress dam to slide or overturn, and as no tensile stresses occur, reinforcing steel is not required.

Hazards of uplift

The thrust-buttress design was developed in the study of a site requiring an exceptionally high dam. The foundation conditions were such that uplift required serious consideration in the design of a gravity section.

In dealing with unknown forces the designer is forced to rely on precedent or make his own guess and usually he must spend much money. For this reason considerable cost and uncertainty is chargeable to the unknown force of uplift, which next to the horizontal water load is the most important external force acting on a gravity dam.

Uplift is caused by hydrostatic pressure acting over an area. The writer doubts that it ever will be accurately measured for any existing dam on a rock foundation, or that it can ever be predetermined accurately in advance of construction.

In design, a guess is made at the intensity of uplift pressure, and a second guess is made at the area affected; these two guesses are multiplied together, and the dam is designed to balance the product. In judging the safety of an existing dam, uplift pressures are sometimes measured, and the process is more accurate to the extent that only one guess is made; but knowledge of the area affected by uplift pressure is just as important as knowledge of the pressure itself. This area is guessed to be zero by optimists, and 100 per cent by those pessimistic ones who take the position that the base of the dam rests on an unbroken continuous film of water. Others guess somewhere between the above limits, but everyone guesses.

Gravity dams have been and can be made safe against uplift and all other forces. There is no question whatever about this. Their safety depends on guesses, however, and the history of gravity dam failures is too often connected with the unknown force uplift. It is desirable to have a type of dam the stability of which is independent of the unknown uplift force. The thrust buttress dam meets this requirement.

The thrust-buttress design for the site mentioned worked out favorably. It was thought desirable to see if it was possible to apply it to still greater heights. The Hoover Dam is the highest yet proposed. For this reason and as a matter of interest, a preliminary design was applied to that site.

Design problems simplified

Buttresses Act as Columns—Drawings in Fig. 1 illustrate the idea as applied to the Hoover Dam site. Water pressure is transmitted to the abutments by the column action of buttresses, and as these are backed up by the abutments, overturning and sliding are impossible. As concrete weighs more per cubic foot than water, no amount of uplift can raise the buttresses or buttress heads off the foundation. All the concrete is used to resist water pressure by compression. No guessed-at amount of dead weight is provided for resisting an unknown force.

The units or sections of the dam were taken as 60 ft. This was considered about the maximum desirable distance between contraction joints. The contact area between the units varies as shown, from 10 ft. in width at the top to 89 ft. at the bottom. The possibility of leakage between the units will probably be one of the points most strongly questioned in this type of a dam. The above dimensions of the contact area were based on the experience acquired at the Don Martin Dam (*ENR*, March 21, 1929, p. 452; Dec. 4, 1930, p. 884; *Proceedings*, Am. Soc. C.E., Dec., 1930), where the contact area between units is 2 meters (6.56 ft.) wide; the joint is closed with one copper seal and drained by one 6-in. hole, as shown by a detail sketch included in Fig. 2. This dam is now holding a head of 115 ft., and there is no measurable leakage between the units. The wider contact area provided in the thrust-buttress design will permit a multiplication of seals and of high-pressure grouting between them, as well as several drainage wells of larger dimensions than those used at Don Martin. It is the writer's opinion that such an arrangement will prevent excessive leakage.

The buttress heads of the tentative thrust-buttress design for the Hoover Dam site are so shaped that the resultant of the water pressure falls at or upstream of the center of the line *A-A* in the enlarged plan of the buttress (Fig. 1). This condition insures that the head will be under compression under all conditions and that the water pressure will have no tendency to open cracks in their upstream faces. The shearing stresses are low, as will be found by analysis. The vertical construction joints and the contact areas between the buttresses and abutments are to be grouted under high pressure after shrinkage has taken place. This, it is believed, will insure the direct transfer of the water load to the abutments.

It may be noted that in the usual arrangement of buttress dams the highest stresses in the buttresses occur where the buttresses are the longest. In the thrust-buttress dam the buttresses are shortest where the stress is greatest.

The maximum stress is due to the

dead weight of concrete with empty reservoir and is computed to be about 35 tons per square foot at the upstream toe.

This thrust-buttress design for the Hoover site is computed to require about 1,950,000 cu.yd. of concrete. Since design and estimate are based on a photographic enlargement of the published topography of the dam site, this figure is of course subject to error. The volume contained in the arch-gravity dam now being built at the Hoover site is 3,400,000 cu.yd.

Conclusions

In summary, it is believed that the following statements are warranted regarding the advantages of the thrust-buttress dam:

1. It cannot overturn.
2. It cannot slide.
3. It is not affected by uplift.
4. It is economical of material as compared with gravity dams.
5. It is capable of development for great heights with moderate pressures.
6. It is susceptible of accurate analysis.
7. The maximum stresses are not affected by temperature changes, shrinkage or water soaking.
8. There is no other type of dam having all the above advantages.

The fundamental idea of dividing a dam into vertical units as in the thrust-buttress design can also be applied to gravity dams, with marked economy over the usual gravity layout (Fig. 2). The Hoover Dam site is again used as an illustration, and the adopted section for the Hoover Dam is taken as a basis. By arranging the layout similar to the thrust-buttress design the height of the dam that acts as a gravity section is reduced from some 700 to 400 ft. The water load below El. 800 is transferred to the abutments by thrust action. Below this elevation sliding is mechanically impossible. If suitable openings are left downstream from the vertical contraction joints, it will be impossible for pressure normal to the axis of the units to be built up by leakage. These openings will also facilitate the cooling of the concrete during the process of placing.

Approximate computations indicate a saving of 900,000 cu.yd. of concrete over the arch-gravity design. A very large saving in riverbed excavation and in concrete placed below low water is also secured.

Engineering direction

The thrust-buttress design was developed in the Mexico office of The J. G. White Engineering Corp., S. en C., by the writer, with the assistance of H. P. Bunger, designing engineer, and J. Chávez Orozco. All the work of the corporation is under the direction of G. W. Caldwell, general manager. H. V. R. Thorne is construction supervisor.

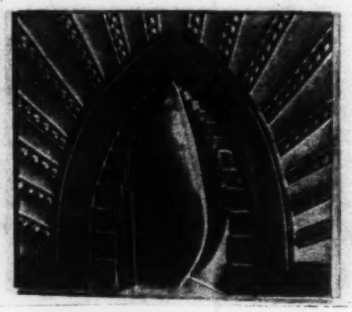
The Building Spandrel of Cast or Sheet Aluminum Alloy

Sand castings so far have found most extensive use, but the lighter die-cast or built-up spandrels of sheets have also been used, both types being produced in varying finishes and designs

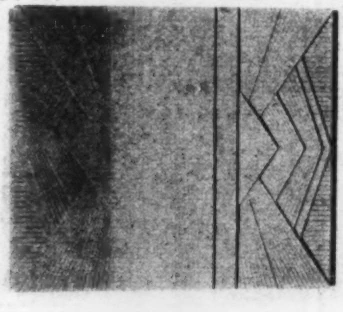
IN A NUMBER of recent buildings the spandrel space between the top of one window and the bottom of the window above has been filled with an aluminum casting or sheet. Among the factors that have dictated the use of this new material are its lightness, non-drip-staining characteristics, resistance to atmospheric corrosion and availability in a variety of shapes, sizes or architectural surface treatments. As the manufacture of aluminum spandrels has not been widely described, the following information may be helpful.

Most of the ornamental aluminum spandrels now in use have been produced as sand castings; in a few instances spandrels have been pressed out of sheet-metal blanks. Sheet-metal spandrels are usually made from 3S alloy, an aluminum-manganese combination containing 1.25 per cent manganese. Cast spandrels are made of 43 alloy, an aluminum - silicon metal containing 5 per cent silicon. Provided that the alloy is made from virgin metals of low iron content, it is quite fluid at temperatures almost down to the freezing point and has a low solidification shrinkage—a combination of properties that makes it possible to cast intricate shapes having both heavy and thin sections without excessive use of chills and risers. As between cast and sheet spandrels the choice is largely a matter of preference. Sheet spandrels are apt to be slightly more costly because of the fabrication charges or die cost.

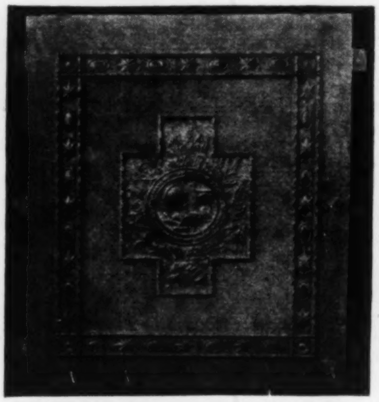
Among the accompanying illustrations



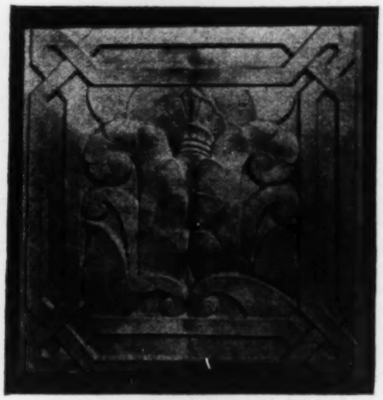
Chrysler Building, New York: the raised portions are polished to produce a highlight effect.



Empire State Building, New York: spandrels weigh from 90 to 240 lb. Sea-gray color was obtained by deplating.



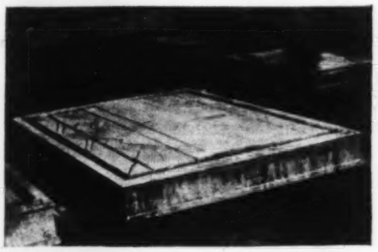
Creighton University, Omaha: spandrels on one of the principal new buildings are sand blasted castings on which the raised parts have been polished.



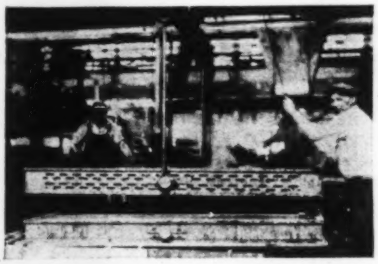
Lincoln National Bank, Fort Wayne, Ind.: spandrels are pressed from two sheet-metal blanks and welded together at the center.

CASTING ALUMINUM SPANDRELS

Drag being rolled over preparatory to drawing pattern.

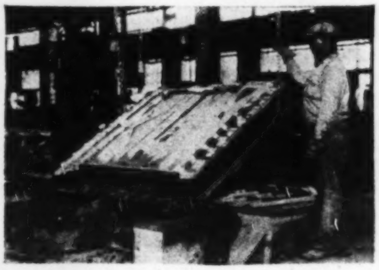


Finished cope ready for the aluminum alloy metal.



Placing cope over drag preparatory to pouring.

Pouring the metal for the aluminum casting.



Finished casting ready to be removed from flask.

are shown spandrel designs utilized on several modern buildings. Many thousands of spandrels are in service, a total of 5,704 cast-aluminum spandrels being installed on the Empire State Building alone. Also a contract was recently let for 7,200 cast spandrels for use on the first three buildings, two of 31 stories and one of 68 stories, of the Metropolitan Square development in New York. The various steps employed in the casting of the Empire State Building spandrels at the Cleveland works of the United States Aluminum Co. are illustrated in the second group of pictures with this article. The flask equipment is entirely of aluminum.

While care in manufacture is necessary, it is stated that very little trouble is occasioned by blow holes in the castings. Extreme care in handling is not necessary for the spandrels are not especially fragile. The usual size spandrel, 4½x5 ft., is cast with a thickness of 3/16 to ¼ in. and weighs between 85 and 90 lb.

A number of different finishes and combinations of finishes may be obtained on aluminum spandrels. The natural color of aluminum is silvery white with a bluish cast, but there are differences in the color, depending on the method of manufacture. The surface of a casting appears darker than that of a sheet-metal product because of its coarser texture. On polishing an aluminum surface the tinge of blue becomes more pronounced, and the surface has a greater reflectivity for light. Sandblasting reduces the reflectivity of the surface and produces a finish similar to that of etched glass. A carborundum blast gives a darker shade of gray due to the deposition of small particles of carborundum. A satin finish is obtained by wire-brushing the surface or rubbing it with an emery cloth. A caustic dip merely cleans the surface.

Varying shades of gray may be obtained by "deplating" castings of the aluminum-silicon alloys. This process corresponds roughly to the anodic treatment of aluminum and is the reverse of plating. Briefly, an electroplating apparatus is employed with the casting as the positive electrode and a slab of pure aluminum as the cathode in a weak solution of sulphuric acid. Electrolysis removes aluminum from the surface and leaves the silicon particles exposed. Since oxygen forms at the positive pole, the surface of the casting is oxidized. The color of silicon is a dark velvety gray similar to that of lead. Varying the current density and time produces different shades of gray.

The color of window glass at a distance resembles that of a carborundum-blasted or a deplated aluminum casting. When spandrels in these finishes are employed, they merge with the windows and give the appearance of one vertical gray line. At the same time the carborundum-blasted and deplated finishes resemble the color an aluminum spandrel will eventually assume after being exposed to the atmosphere for some time. Weathering naturally will cause the spandrel to lose some of its reflectivity for light and assume a darker color, but for the most part the change in color is due to the deposit of foreign particles from the atmosphere. Because of this, a polished or smooth surface remains bright much longer than a sandblasted or a cast surface, and a sheet-metal spandrel retains its original lustre longer than a cast spandrel.

Large Testing Machine Built for California Laboratory

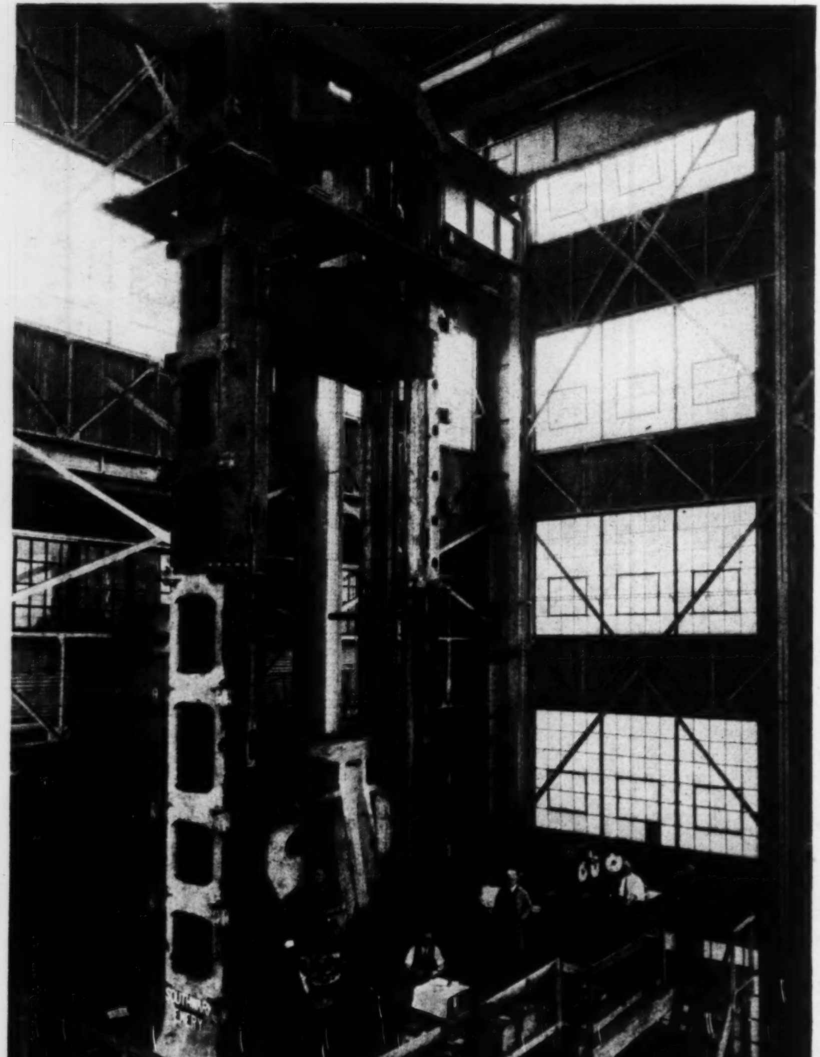
THE COUNTRY'S largest universal testing machine recently was completed and put through a series of tests in the shops of the Baldwin-Southwark Corp. at Eddystone, Pa. It is now on its way to the University of California, where it will be installed in the new testing laboratory.

The machine is able to test columns of a maximum length of 33 ft. 6 in. in compression under loads up to 4,000,000 lb. and will take tension specimens of the same length less the machine stroke required for the test. The maximum capacity in tension is 3,000,000 lb. Horizontal dimensions of test specimens are limited only by the spread between the main columns of the machine, which is 10 ft., and by the table length of 12 ft. The table of the machine as set up in the shop at Eddystone is at the level of the temporary platform shown in the accompanying illustration, but in the testing laboratory of the University of California it will be at floor level so that specimens for testing may be delivered on the table by truck.

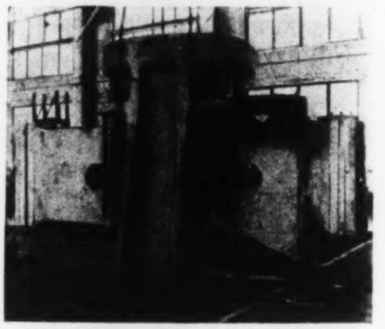
This new Southwark-Emery testing machine is hydraulic in operation, the load being produced by oil at a pressure of 2,500 lb. per sq.in. acting on a 46-in.-diameter ram in a cylinder below the table. The load is transmitted from the ram to the specimen through two vanadium-steel screws 12 in. in diameter. Screws are used in preference to plain bars for convenience in adjusting the position of the lower crosshead. During loading there is no movement of the nuts and screws relative to one another.

Compression tests are carried out between the lower crosshead and the table, while tension tests are made between the upper crosshead and the yoke around the lower crosshead. The total stroke of the lower crosshead in testing is 48 in. In both compression and tension testing the lower crosshead moves downward. In order that the heavy weight of the moving part, about 200,000 lb., may be returned to position preparatory for new tests, two 13-in.-diameter pull-back cylinders are provided. These cylinders also serve another purpose. In the failure of a specimen, either in tension or in compression, there is released in a small fraction of a second an enormous store of energy. The cylinders and rams, together with four nests of heavy springs, absorb the shock and damp it out without damage to the structure.

The lower crosshead is one of the unique features of the testing machine. The lower side of the yoke around the crosshead is machined to receive the block for compression testing, and the upper head of the yoke contains the chrome-nickel grips for tension testing. These grips are handled by air cylinders as they are too heavy for manual manipulation.


4,000,000-lb. hydraulic testing machine assembled for calibration before shipment to the University of California.

The principal unit of the weighing system is the Emery support or hydraulic capsule, a very heavy inelastic cylinder containing a loose-fitting piston, the end of which is covered by a diaphragm. The movement of this piston is only a few thousandths of an inch at the most, and the oil with which the capsule is filled, when displaced by this motion, causes a change of shape in the elastic tubes to which the capsule is connected. These elastic tubes control four indicators on an adjoining instrument board. The ranges of these indicating instruments are: 0 to 4,000,000; 0 to 2,000,000; 0 to 525,000; and 0 to 200,000 lb.


The lower crosshead is designed to damp the shock of failure of a test specimen.

One of the unusual features of the machine is the inclusion of devices for maintaining a constant load over an indefinite period; for application of a load at constant rates of load increment; and start, stop and inching buttons.

When assembled in the laboratory of the University of California, it will be equipped with an elevator for operators to examine any part of the test specimen, with telephone connections from a glass-inclosed instrument and control booth, and with loud speakers to keep operators or observers informed as to progress.

In the preliminary tests of the machine a tension specimen 8$\frac{1}{16}$ in. in diameter failed at 3,095,000 lb., and a 30-in.-diameter concrete specimen 60 in. high failed at 2,950,000 lb.

Operation of the machine in the laboratory of the University of California will be directed by Prof. R. R. Davis.

The new testing machine is exceeded in capacity by a universal machine in the Gross-Lichterfelde laboratory in Germany, which has limits of 6,600,000 lb. in compression and 3,300,000 in tension. A somewhat similar machine was built at Middlesborough, England, for Dorman, Long & Co., for testing members of the Sydney Harbor bridge. It is a horizontal machine and will take test specimens 50 ft. long and 45 in. square. It has a load limit of 2,800,000 lb. For transverse testing it will take girders of a span length of 20 ft. The American Bridge Co. at its plant at Ambridge, Pa., has a tension-testing machine for eyebars up to 35-ft. length. It has a capacity of 4,000,000 lb. in tension. The Roebling plant at Trenton has a universal machine of 2,000,000-lb. capacity, which will take specimens up to 25-ft. length. The U. S. Bureau of Standards in Washington is equipped with three large machines, a vertical universal machine of 2,300,000- and 1,150,000-lb. capacity, taking 24-ft. specimens; and a horizontal compression-testing machine of 10,000,000-lb. capacity, taking 24-ft. specimens. A 4,000,000-lb. compression machine was installed recently in the Denver laboratory of the Bureau of Reclamation.

Problems of Ready-Mixed Concrete Industry Reviewed

Second annual convention shows active interest in technical problems—Overproduction looms as an obstacle to profitable operation

AN ATTENDANCE of 210 and a closely followed program indicated increasing activity of the two-year-old National Ready-Mixed Concrete Association at its second annual convention two weeks ago at Pittsburgh, Pa. Four leading papers were read, and one session was given up to topical discussions. So must interest was evidenced that the three scheduled sessions were increased to four.

The principal papers were: ready-mixed concrete from the viewpoint of the architect and the engineer, by Cloyd M. Chapman, consulting engineer, New York; control tests of ready-mixed concrete, by Miles N. Clair, Thompson & Lichtner Co., consulting engineers, Boston; purchase specifications for ready-mixed concrete, by R. B. Young, consulting engineer, Toronto; and standard methods of testing concrete, by A. T. Goldbeck, engineer, Crushed Stone Association, Washington. Topical discussion was confined closely to production and merchandising problems.

Economic and business problems

Secretary V. P. Ahern in his report outlined the pressing needs for association activity to be increased membership and price stabilization. He said:

> At the present time the membership of the association is entirely inadequate, although even with a limited number of companies actively participating in its work the organization represents a very substantial percentage of the total production of ready-mixed concrete . . . In the field of economic research the ready-mixed concrete industry has made no progress whatever. There is a vital need for collection and distribution of reliable data concerning the total production and value of ready-mixed concrete, monthly and annually. . . . The information would be of immeasurable value in assisting the association to combat what is unquestionably the most serious and the most dangerous problem that the industry is facing: reckless and uncontrolled expansion of the facilities for producing ready-mixed concrete, to the point where we shall be afflicted with the evils that attend overproduction. . . . There is more than one sign that the ready-mixed concrete field, in some sections at least, is crowded with too many companies. The immediate result, due to desperate price wars, has been a decline in quality and service, and unless we can, as an association, find some practical solution to these disturbances, we shall have to prepare ourselves for an active sales resistance.

Stanton Walker, director of the engineering division, called particular attention to the work being done in the preparation of a comprehensive and accurate purchase specification for ready-mixed concrete, which is a most important requirement of the industry. It was felt that such a specification, to be most effective, should be formulated by a group entirely independent of the industry and by one thoroughly familiar with its problems. President J. E. Burke addressed a request to committee C-9 on concrete and concrete aggregates, of the American Society for Testing Materials, asking its cooperation in a study of that important problem. As a result of this request, a special subcommittee was formed with the primary object of preparing a specification covering the proportioning, mixing, delivery, inspection and acceptance of ready-mixed concrete. Its work is under the chairmanship of R. B. Young, consulting engineer of Toronto, Canada, and Canadian vice-president of the association.

Among the problems for study Mr. Walker cited uniformity of strength, design of proportions, methods of sampling, length of haul, time of mixing and equipment. Speaking specifically of equipment it was said:

> There are many studies of equipment that should be and are being conducted. These involve design of drum, rate of rotation, control devices and many other problems. The general use of ready-mixed concrete has brought about the need for special equipment. Much of this has been developed, and more is in the process of development. Special consideration is being given at this time to methods for the distribution of concrete from the truck, particularly in highway construction.

Many different manufacturers are furnishing excellent equipment. No comparisons can be made, because continuous improvements are being developed, and a comparison today may not be accurate tomorrow. It can be said emphatically, however, that the standard equipment available today, properly handled, will produce concrete meeting the most rigid requirements. The selection of equipment, therefore, is dictated by the nature of the market and other local conditions and by the economy in operations.

Research Outstanding at Sand and Gravel Meeting

Annual convention shows sound membership and financial condition of national association — Technical papers and report on research notable

KEEN INTEREST in business and technical discussions and good attendance at the sessions characterized the meeting in Pittsburgh, Pa., last week, of nearly 500 producers and engineers at the annual convention of the National Sand and Gravel Association. Following a year of business depression the number registered was 476, as compared with 561 in 1931 and 425 in 1930. A further indication of vitality was the report of the association secretary, V. P. Ahearn, that the industry "in these times of adversity has not withdrawn even in the slightest degree the measure of its support" to the technological and research work being carried on by the association.

Economics and marketing

The speakers on the program covered the wide range of subjects of interest to producers of aggregates, and particularly to producers of sand and gravel.

Willard T. Chevalier, publishing director of *Engineering News-Record*, discussed problems in the construction field. He emphasized the necessity of greater efficiency of production and disclosed the fallacy of the reasoning that would dictate the replacement of machines by hand labor as a means of relieving unemployment. He pleaded for intelligent competition to insure progress, rather than the protection of the inefficient by the various plans to curtail and regulate production.

Colonel Chevalier's paper furnished a valuable background for a most excellent discussion on stabilization of industry, presented at another session by Dr. Ralph J. Watkins, director of the bureau of research, University of Pittsburgh. Doctor Watkins analyzed the various plans that had been advanced for industrial stabilization. He pointed out that he placed his faith in education and information rather than in coercion. He advanced the thought of an endowed institution, independent of any political or business group, to study business conditions and to furnish information on its trends. Doctor Watkins' paper was discussed by Colonel Chevalier.

A paper on sales lubrication, by E. J. Doyle, president of the Doyle Gasoline and Oil Co., Roslyn, N. Y., stressed the importance of more efficient merchandising and the study of sales problems.

Developments in technology

The technology of the production and the use of sand and gravel received the major share of attention in the rest of the program. One session, arranged through the cooperation of the U. S. Bureau of Mines, was devoted to operating problems and consisted of papers and discussions prepared by producers of sand and gravel. The leading papers were on methods and costs of mining, and preparing sand and gravel at the plant of the Ward Sand and Gravel Co., Oxford, Mich., by F. L. Ward; methods and costs of mining, and preparing sand and gravel at the Clowdy plant of the Dallas Washed and Screened Gravel Co., Dallas, Tex., by Rollin J. Windrow; and sand and gravel dredging methods and costs at the plant of J. K. Davison & Bros., Pittsburgh, Pa., by George W. Williamson.

Another session had to do principally with concrete and specifications for aggregates. The leading paper was a most complete exposition of designing concrete-paving mixtures by water-cement-ratio trial method, presented by F. H. Jackson of the U. S. Bureau of Public Roads. His paper discussed, first, the theoretical basis for designing pavement mixtures by the water-cement-ratio trial method; second, certain results that have been secured in practice; and, third, the practical limitations of such a method both from the standpoint of testing and of administration. Mr. Jackson's paper was of especial interest on account of the introduction of design methods in the construction of highways by several state departments, and the effect that such methods have had on the competitive relationships of producers. H. S. Mattimore's discussion of aggregate specifications and P. J. Freeman's outline of specification and production problems from the viewpoint of the engineer did much to clarify in the minds of sand and gravel producers the basis and importance of various specification clauses.

A study of local pit production in Minnesota, by J. W. Kelly, described the results of a field investigation of wayside pit competition in that state. Competition from the local pit, operated for the job at hand, has always presented a most serious problem to the established aggregate producer, and consequently Mr. Kelly's discussion was on a subject of foremost interest.

The prominence of low-cost-road construction indicated the desirability of one session devoted to descriptions of paving materials for that type of construction. Bernard E. Gray, highway engineer of the Asphalt Institute, prepared a paper on the use of asphalt in gravel for road and street surfacing, which, in Mr. Gray's absence, was read by C. N. Conner of the American Road Builders' Association. Mr. Gray's paper was discussed by Mr. Conner and by George E. Martin, consulting engineer of The Barrett Co. A valuable complement to Mr. Gray's paper and the discussions of it was furnished by a discussion of various bituminous materials, presented by W. J. Emmons. The session was closed by a paper on the use of concrete in stage construction of highways, presented by E. M. Fleming, of the Portland Cement Association.

A paper on the use of gravel for railroad ballast was presented by Charles B. Stanton, professor of civil engineering, Carnegie Institute of Technology. A paper by H. W. Heinrich, of the Traveler's Insurance Co. dealt in detail with practical safety methods applied to the sand and gravel industry.

Research activities

A full report by Stanton Walker, director of the engineering and research division of the association, gave figures of routine tests and investigations for members, a statement of publications issued and a summary list of some thirteen research studies under way. The three new studies of the present year are: (1) method of making accelerated sodium sulfate soundness tests of fine and coarse aggregate; (2) effect of quality of cement on comparisons of concrete making of aggregates; and (3) drainage tests of sands. All these studies are still in progress, and results are not ready for announcement. In general it is said of the soundness test that the sodium sulfate test "appears to offer information of assistance in judging the ability of most aggregates to resist the destructive action of the weather."

Tight Municipal Finances Affect Public Works

THE YEAR 1931 became an increasingly critical one for municipalities as the months passed. The first month of 1932 saw conditions becoming more serious, with no signs of early improvement.

Municipal bond sales in 1931 were the lowest since 1923, the latter year being the lowest in the past ten years. But the spread between the high year of 1927 and the low year of 1923 was not so great as might be expected, the figures in millions of dollars being 1,478 and 1,135, against 1,252 in 1931, while the latter year was not far below the 1,383 total of 1930.

Bond sales for January, 1932, excluding $100,000,000 of New York City short-term securities, totaled a little more than $33,000,000, compared with nearly $50,000,000 in January, 1931, and almost as much last December. According to *The Daily Bond Buyer,* from which these figures are taken: "The effect of the current credit crisis on this type of borrowing [state, county, city, etc.] is shown by the figures for the current months as against a monthly average in 1931 of approximately $100,000,000, new issues sold in four months ended Jan. 31, 1932 (excluding the $100,000,000 New York City short-term emergency loan) amounted to only $151,00,000, or less than 40 per cent of the normal value." The peak January of the past ten years was in 1927, when nearly $175,000,000 of state and municipal bonds were sold.

The total of the bond issues submitted to popular vote in 1931 was less than half of that for 1928 and about three-fourths of the total for 1929; but, notwithstanding this falling off, more than a fifth of the total of the bonds voted on were defeated. The percentages defeated in the three preceding years rose year by year to 60 per cent in 1928, indicating that those responsible for putting bond issues to referendum vote became more and more conservative as the years passed but still continued to overestimate the unwillingness of the people to add to their funded obligations.

In January just passed, 30 communities voted in favor of bond issues and 12 against them, the corresponding totals being just under $4,000,000 and just over $1,400,000. The bond issues approved in January, 1931, totaled more than double those voted last month. Most of the approvals in January, 1932, were for small issues, the four largest ranging from $650,000 to $375,000 and aggregating more than $1,930,000, so that the remaining 26 approvals averaged only $80,000. The four largest defeats in January, 1932, ranged from $275,000 to $200,000 and totaled $971,000, leaving an average of less than $60,000 for the other eight defeats. The average amount of the 42 issues approved or defeated last January was about $130,000, illustrating further the temerity of municipal authorities in putting bond issues to popular vote.

The preceding summaries deal with state and municipal financing only.

More comprehensive figures on means provided to finance not only public construction but private as well, much of the latter concerning utilities serving city and countryside, have been compiled by *Engineering News-Record.* These show a decline in public and private construction fund totals for the first 23 days in January from $243,000,000 a year ago to only $15,000,000 this year, which is very significant in view of the fact that for the entire year just passed the combined public and private financing for new construction was half as much as for 1928 and more than half the 1929 figure. Four-fifths as much was provided for public works in 1931 as in 1929.

A great factor in the outlook for construction work financed by bond issues is that during 1931 the cost of municipal bond money rose from the lowest to the highest level in a quarter of a century, or from under 4 to over 5 per cent. During the last few weeks bonds offered at 5 per cent or higher have brought no bidders, but there have been some notable exceptions.

Curtailment of bond funds is not the only factor that is cutting down public-works construction for 1932. For reasons too numerous to list here, there is today an unprecedented demand for the reduction of tax rates. This demand finds expression just now as municipal budgets are being formulated and submitted at public hearings. Many cities are forced to cut their budgets because they are in financial straits; a much larger number are being importuned by taxpayers to cut budgets and reduce taxation. The cities in financial straits have felt it necessary to hold up not only public-works construction financed from bond issues but also to cut heavily, if not abandon completely, the usual yearly construction financed by taxation and by benefit assessments. Nor is this all. Public services of various kinds, such as street repairs and cleaning, garbage and refuse collection and even fire and police departments are being reduced, and with these reductions cuts are being made in the materials and supplies ordinarily used by these services.

Altogether, present indications are that the year will see heavy reductions in municipal construction work and, in many cities, in ordinary operation and maintenance. Reductions of municipal budgets will tend to restore taxpayers' and money-loaners' confidence with respect to the financing of subsequent years.

Decisions in Engineering Law

By Herbert Braasch

Attorney at Law, New York City

DECISIONS reached in cases tried in the higher federal courts and in the state supreme courts are summarized in these articles appearing from time to time in *Engineering News-Record.* —EDITOR.

Ownership of Materials Delivered to Job

Frank Stratton had the lathing and plastering subcontract on a theater, store and apartment building in Detroit. He ordered certain necessary plaster forms specially constructed for the job and they were delivered to the site, where they were stored pending the time when they would be needed.

Stratton and the general contractor's agreement comprised the standard form of the American Institute of Architects, and section 6 of this standard form clause (*a*) provided:

"It is understood settlements on within contract are to be made on or about the 10th day of each month of 90 per cent of the value, based on contract price, of labor and materials incorporated in the work and of materials suitably stored at the site thereof up to the 30th day of the preceding month, as estimated by the architects, less the aggregate of previous payments; and upon substantial completion of the entire work a sum sufficient to increase the total payments to 100 per cent of the contract price shall be paid."

Payments were made under this provision upon the architect's certificate, which expressly stated the payments did not constitute an acceptance of the work done or the materials furnished. On each payment Stratton furnished an affidavit showing payment for all materials and labor and also a waiver of lien. The owner was unable to proceed with the operation and sold all rights to the partly constructed building to the A. C. Sisman Co. The subcontractor was unable to come to an agreement with the new owner and did not complete his contract. He had not been paid for the plaster forms stored at the site.

Not wishing to proceed further with the work, the plastering subcontractor claimed the materials stored on the job. The question arose whether title to these had already passed or whether this was still the subcontractor's property. The contract was silent on this point. Generally delivery of materials to the place where they are to be used in a structure and partial payment for them are not enough without other proof that title was intended to pass at that time. To ascertain the intention of the parties where the contract is silent regard must be had to usages of the trade and other circumstances. Neither the furnishing of affidavit under the lien law and waiver nor the furnishing of materials and partial payment are decisive.

The subcontractor had from time to time received money from the mortgagee on behalf of the owner, which money was advanced upon a construction loan. It was held the subcontractor must have realized the mortgagee was advancing money on security and the only reason for making payments was on the strength of the security to which he had added his materials which could only be done by transferring title. There being no contract term to the contrary, it is implied this was the intention of the parties.—*Stratton vs. A. C. Sisman Co., Michigan.*

Awards by City Council Without Competition

Danville, Ky., which had no established board of public works, desired to erect a municipal building. The city council had plans and specifications prepared and bids were called for. All of them submitted exceeded the money available and all were rejected. A contract was then entered into by private negotiation with one of the bidders, who offered to construct the building for the funds at hand after certain revision of plans.

The award was attacked by one of the rejected bidders who was a taxpayer. Kentucky statutes authorized the city council to establish by ordinance a board of public works; where no board of public works had been so created, the council and such agents as it designated were to perform the duties of the board of public works. The provision was, "When the board shall deem it advisable to make a contract for the execution of any work or the purchase of any supplies or material for any matter under its charge, it shall cause to be made a careful estimate of the cost of such work or material. In all cases where the estimated cost of any expenditure exceeds $500 the board shall transmit to the council with its recommendation an ordinance authorizing the expenditure with an estimate of cost. Upon the passage of such ordinance it shall be the duty of the board to advertise and let the contract to the lowest responsible bidder."

The city council claimed this provision relating to the board of public works did not apply to the city council and that the council was free to let such contract, though an inferior body as the board of public works could only do so after competition by bidders. The court, however, held the council was bound in the same way as the board of public works. The statutory provision was to safeguard the general public by requiring competition for public work. The same reasoning applies as well to the city council as to a board such council might create.—*City of Danville vs. Shields, Kentucky.*

From Job and Office

Hints That Cut Cost and Time for the Contractor and Engineer

Wood Penstock Speeds Use of Austrian Hydro-Electric Plant

VERSATILE planning and efficient construction saved nearly a year's time in the utilization of a large hydro-electric plant in Austria. The Vermut plant in Voralberg, Austria, was being built at an elevation of 5,650 ft. about sea level. In September, 1929, it became apparent that the concrete dam could not be finished before the winter storms would put an end to construction. It was therefore decided to built a temporary earth dam and to connect this with the completed power plant through a temporary penstock. As it was impossible to procure either steel or concrete pipe at such short notice, wood was adopted as the material. On Oct. 15 a contract was awarded to Karl Kubler A.G., Stuttgart, Germany, for supplying and laying 1,410 ft. of 5.9-ft. pipe with a capacity of 353 sec.-ft., to be completed by Nov. 20. The pipe was assembled in place, using 2-in. wood staves. Despite the fact that snow began to fall late in October, the work, including connections to the dam and turbine, was finished Nov. 21. The total cost of the temporary construction was 150,000 marks. Had this not been expended, no return would have been secured that winter from an invested capital of 30,000,000 marks.

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Expansion Joints in Bridge Approaches

EXPANSION JOINTS in pavement slabs on bridge approaches have been adopted by the department of highways and public works of Tennessee as a means of avoiding the effects of settlement in the approach fills. Prior to the adoption of this policy, the department experimented with an offset in both ends of the bridge-floor structure to carry the abutting ends of the pavement slab. With this construction, the approach sections of the pavement slab were heavily reinforced. This design resulted in the cracking of the slab about 10 ft. from the end of the bridge, due to the fact that the reinforcement and the depth of the slab were insufficient to provide the beam action necessary to bridge settlement in the fill. The present practice is to use three $2\frac{1}{2}$-in. expansion joints for the full roadway width at both ends of the bridge. One is placed between the end of the bridge floor and the abutting end of the slab, the second 12 ft. back from that and the third 12 ft. farther. All three are filled with a bituminous mastic. The two 12-ft. sections of the pavement slab also are heavily reinforced in both directions with $\frac{1}{2}$-in. deformed bars. The surface is kept smooth by filling depressions with bituminous material as the sections settle. In case settlement becomes excessive, the sections may be removed and replaced after the fill has stabilized. Thus far this has not been necessary.

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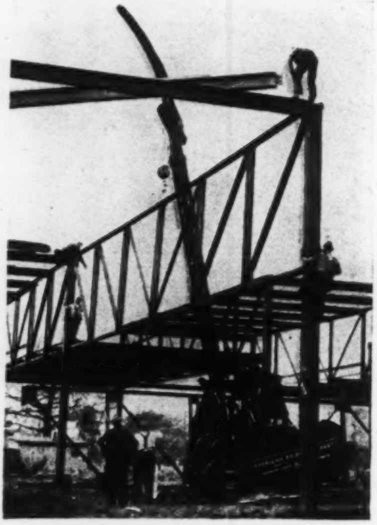
Tractor-Derrick Rig Erects 350-Ton Steel Building Frame

IN ERECTING a new building for the Raymond Bag Co. at Middletown, Ohio, the American Bridge Co. effectively used two new pieces of erection equipment—a tractor-derrick and a steel trailer wagon. The building was one story high, with wings 80x120 ft., covered an area 180x445 ft. and contained 350 tons of structural steel. Not only did the tractor derrick erect the entire framework, but it also unloaded the steel at the railroad siding as well.

As shown in the accompanying illustration, the rig consists of a 60-hp. crawler tractor, on the rear end of which is mounted a heavy structural-steel A-frame and a 30-ft. boom with a 12-ft. curved extension. A double-drum hoist mounted over the tractor frame at the front of the machine powers the main hoisting drums. A small four-drum shelf hoist is mounted on the side of the tractor and furnishes the swing lines and the wire-rope runner lines. The main hoisting engine serves as a counterweight but is supplemented by an additional counterweight of steel rails hung on a shelf in front of the radiator. The legs of the A-frame serve as spuds to fix the derrick in position when lifting a load, and they terminate in broad flat castings to give the necessary bearing on the ground. These spuds are operated by screw jacks in the lower arms of the A-frame, which allow the flat castings to be raised or lowered as desired for blocking purposes.

Setting a 3-ton roof truss with tractor-derrick rig.



On the Middletown job the steel, received in gondola cars, was unloaded by the tractor-derrick either onto the ground or directly onto a 7-ton-capacity steel trailer wagon. This wagon was then hauled to the job, where it was slowly pulled along as the material was skidded off its I-beam bolsters at the proper points. The top flanges of these bolsters were crimped downward at either end, making unloading an easy matter. For hauling the long roof trusses the frame of the wagon was removed, thus providing two sets of trucks that could be spread any distance apart.

The tractor-derrick lifted the steel directly into place in the building. The 3-ton roof trusses, received riveted up, were the heaviest erection pieces, but were handled readily by the derrick, which was able to maneuver with such a load hanging from the falls. Purlins were set with the 12-ft. boom extension that is equipped with a separate runner line. Although part of the site for the building was covered with soft deep mud, no difficulty was experienced in setting the steel with this equipment. Both the tractor-derrick and the trailer wagon are patented.

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Sugar in Lime Mortar

By Leo G. Hall
Downers Grove, Ill.

DURING the summer of 1922 the writer laid up a small brick test pier in mortar consisting of one part hydrated lime, four parts sand, and water in which 3 per cent of cheap brown sugar had been dissolved. This mortar set hard like a portland cement mortar in a few hours, though it was kept wet. A similar control pier built with the same mortar, except that the sugar was omitted, showed no setting tendency.

These piers were recently destroyed to make room for a building, being then about eight years old. The lime-sugar mortar was as hard as a good portland cement mortar, and showed equally good adhesion to the brick. It showed good crystallization under the microscope, which the control mortar did not. In point of material cost, the lime-sugar mortar compared favorably with portland cement mortar. In plastic workability, it was fully equal to the lime mortar without sugar.

Parenthetically, an attempt to slake lime in water containing sugar resulted in a coarsely gritty substance entirely lacking plasticity. The sugar must be added after hydration.

While there have been a few isolated notices in the press on the successful use of sugar to set lime mortar, in view of the demand for a mortar combining the plasticity of lime with the hardening qualities of portland cement, it seems that this possibility has not received the consideration it deserves.

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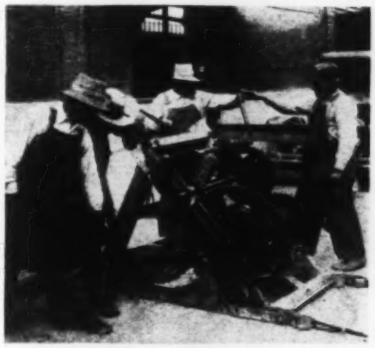
Old Railroad Culvert Used for Water Pipe Crossing

By **A. E. Bennet**
Commissioner, Water and Sewer Department, Aberdeen, S. D.

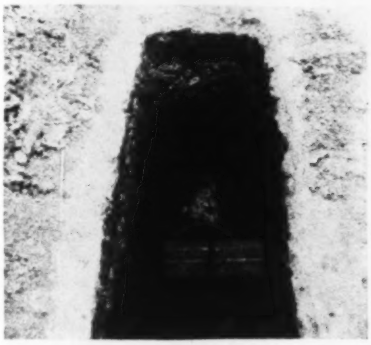
A CROSSING of the wide right-of-way of the C.M.St.P. & P. Ry., in Aberdeen, S. D., by a new 12-in. cast-iron pipe line was made economically by pulling the pipe through an old 30-in. cast-iron culvert by means of a hand winch and steel cable. There were thirteen tracks, three depot platforms, two freight platforms and a freight shed to pass under, a total distance of 320 ft. Fortunately, at some time in the past a 30-in. cast-iron culvert had been installed near the place at which the desired crossing was to be made and it was decided to make use of it for the pipe crossing. In order to utilize the culvert it was necessary to joint the pipe a length at a time and to push or pull it, thus jointed, into the culvert. For this reason flanged pipe was used.

A ⅝-in. steel cable was first threaded, double, through the culvert. The two loose ends were then fastened to the drum of a winch and the loop was threaded through the first pipe. A 6x6-in. oak block was thrust through it to secure bearing and pull on the back end of the pipe. When this length had been pulled nearly into the culvert another length was lowered into the trench and the looped cable pulled back with a smaller winch and threaded through the second pipe. The two were then jointed and the pulling process was repeated.

The winch used was of the double-geared drum type, with an over-all mechanical advantage of 80 to 1 from the crank handles to the cable drum, and was operated by four men. The weight of the pipe on the final pull was 24,000 lb. A large quantity of dirt was also pulled through, forced ahead by a bulkhead on the first pipe. Some difficulty was caused by poor joints in the old culvert, which had been opened up by irregular settlement under the railroad tracks. This difficulty was overcome by a curved steel shoe on the front end of the pipe and by guides made of short pieces of 2x4-in. timber, beveled at the end, firmly wired to the sides and top of the pipe.



Hand winch and steel cable (above) used to pull the 12-in. pipe through the culvert. Blocks (below) placed in a loop in the cable provided bearing against the end of the pipe.



The total operation required a crew of seven men working eight hours for ten days, including all preparatory work and experimenting with methods. Upon completion the line was subjected to a pressure of 55 lb. with a loss of less than 2 lb. in fifteen minutes.

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Splicing Tracing Cloth to Produce Strong Smooth Joints

By **Norris Bostwick**
Assistant Engineer, Metropolitan Water District, Los Angeles, Calif.

SPLICING and patching of tracings can be readily accomplished by the use of collodion or similar cement of cellulose base, using ether or acetone as a solvent. Any one of several trade preparations, such as Newskin and Dupont Household Cement, is quite satisfactory, but flexible collodion containing castor oil does not produce good results. Butt joints are superior to lap joints, both in strength and appearance. There is no difficulty in ruling or lettering across a well-made butt joint, and only a slight streak is evident on blueprints. A closely matched joint may be secured by first lapping the edges and then cutting through both thicknesses with a sharp blade held against a straightedge. If the portions of the tracing to be spliced tend to curl, the edges should be brought together with the convex side upward. A small groove will thus be formed along the seam. A medicine dropper will be found useful in applying the collodion or cement. After drying, a light coat of cement should be placed on the reverse side. There is no advantage in making the width of the cement application more than ⅛ in.

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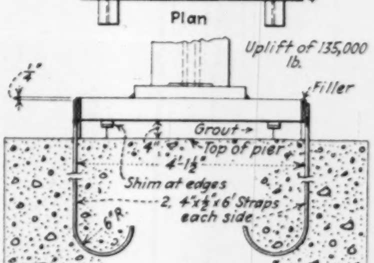
Anchoring Billets and Columns by Welding

By **Anthony S. Coombs**
The Whitney Engineering Co., Boston, Mass.

THE EFFECT of an upward water pressure on the basement floor was one of the conditions to be met in connection with the construction of an extension to the commercial steam-heating plant at Kneeland St., Boston, for The Edison Electric Illuminating Co. This floor consists of a heavy reinforced-concrete slab carried by steel beams and girders to the columns. The columns and billets rest on concrete piers that extend to concrete-pile caps about 20 ft. below the basement floor. A part of the basement floor

Welded detail for anchoring billet and column against uplift.



covers an area over which the superstructure is not to be built until later. The basement floor, as constructed over this portion, is made watertight, with stub columns projecting above the floor for the future extension. This results in a considerable upward pressure transmitted to the columns in this section in excess of the weight of the floor, which pressure must be resisted until the weight of the future superstructure is added. To have used anchor bolts through the billets would have required drilling through two heavy billets and, in addition, an expensive bracket connection between the billet and column stub. To avoid these difficulties the anchorage was made by welding, as illustrated in the accompanying sketch.

Steel hook straps, 4x½ in., were concreted in place with the pier work, being placed 1½ in. farther apart than the width of the lower billet to allow for some variation in the size of the billet. Holes were provided in the upper ends of these straps so that they might be hung by bolts or rods at the proper height while the concrete was being poured. After the billet was placed, one filler of the proper thickness, and wider than the straps to allow for a fillet weld, was placed between each strap and the billet. The upper billet was welded to the lower billet with fillet welds, as shown, after which the column stub was placed in position and welded to the upper billet. The basement-floor steel was in turn connected to the column stubs by means of riveted connections, as the job was in general shop- and field-riveted. The 3-inch 15.7-lb. beams were provided as skids for ease in setting and shimming the lower billet and also for making possible proper grouting under the large billet.

The anchorage was completed through the piers and into the pile caps by means of hooked reinforcement rods and dowels, the weight of the pier and pile cap furnishing sufficient hold-down weight.

Laying Telephone Cable Underground

SUCCESSFUL experimentation with mechanical laying of underground cables over long distances in the Southwest has led the American Telephone & Telegraph Co. to use this method in constructing a 75-mile line over the difficult territory between Syracuse and Watertown, N. Y., where winter weather is severe and underground lines have unusual advantages. After the line had been located and the right-of-way secured, a limited amount of right-of-way preparation was economical, in order to remove major barriers and to prepare, where necessary, for river and creek crossings. With this work done a single standard rooter plow, drawn by a tractor, was used as a pilot machine to feel out the ground over which the heavier cable-laying apparatus was to pass. This machine made a cut about 25 in. deep. During the preliminary operation the cable reels were distributed at 1,000-ft. intervals along the right-of-way.

Laying underground telephone line in New York State.

The next operation was to lay the cable at a depth of 30 in. with a special cable-laying plow drawn by two 60-hp. tractors in tandem. The narrow trench-like opening left after the passing of this unit was closed by a backfiller attached to the rear of the cable reel. To develop additional power for passing through soft ground the front tractor was equipped with a winch. Cable was laid at a rate averaging 12,000 ft. per day. During one period of only five hours and five minutes this outfit actually laid 18,790 ft. of cable. Aside from the tractor driver, the crew included a foreman, three helpers and four labo ers to open and close fence gates a repair fences.

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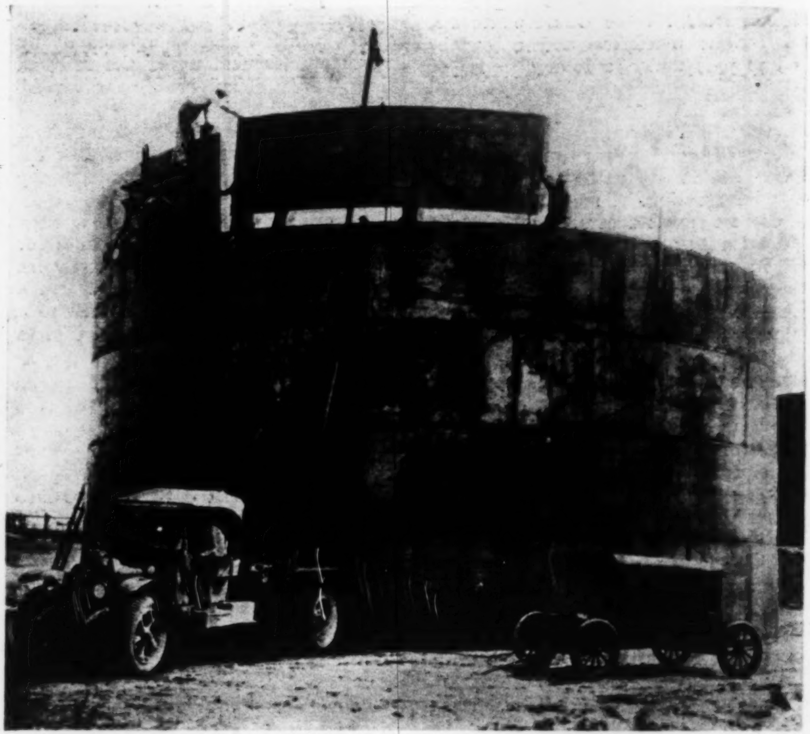
Welding Large Field-Storage Tanks

LARGE storage tanks are now bein completely welded in the field. Th accompanying illustrations are of 20,000-bbl. tank at Corpus Christi, Tex but recently there have been erected number of much larger tanks (80,00 bbl.) also completely arc-welded. N fitup bolts are used either on the shell bottoms or roofs. On this 20,000-bbl tank a truck-mounted derrick of homemade design was used to lift the shell plates into position, where they were tacked and then clamped by men working on a wood scaffold inside the tank. A roller-mounted cage riding on the top edge of the plates on the outside provided a platform for the finish welder. An average of about 16 ft. of welding per hour on the rings and between 25 and 30 ft. per hour on the bottom and roof was made. According to the Lincoln Electric Co., whose shielded-arc method of welding was used, no particular preparation was made on the plates for welding, and in general they were used as they came from the mill. Since nothing over ¼-in. plate was used, it was unnecessary to run more than one bead on any joint.

Equipment used to field-weld oil-storage tank consists of a home-made truck derrick, mobile welding machine and traveling scaffold cage for welder.



Letters to the Editor

Laboratory Tests on River Cutoffs

Sir—Referring to the article by Herbert D. Vogel in your issue of July 16, 1931, p. 84, entitled "Application of Model Research to Mississippi Flood Problems," permit me, first of all, to call attention to what appears to be an error on the part of the printer. On p. 87, the second to eighth line, inclusive, in the third paragraph, beginning with the words "that they are reduced above" and ending with the words "no change in stages a," should evidently be transposed to the bottom of the column after the words "by the same degree." Unless such transportation is made, this portion of the article appears to be meaningless.

I desire to record my dissent from the conclusion reached by Mr. Vogel from the experiments on the model of the Greenville bends in the Mississippi River. He states, "The model showed a maximum lowering of 2.2 ft. due to a cutoff at Tarpley Neck, the influence being felt for a distance of 45 miles above with no change below," and then concludes that the results obtained contradict

> the old theory, offered first in this country by Humphreys and Abbott, that stages are increased below a cutoff by the same degree that they are reduced above, but the proof presented by the model appears irrefutable. In more than a hundred sets of observations the same general effects were observed, and in no case was there an increase below, except for a slight increment produced temporarily by reservoir drawdown. Following hydraulic adjustments of the river there can be no change in stages a few miles downstream from the cutoff, since the same amount of water is coming down as before the cutoff, and no change has been made in the resistance offered to flow." (Quotation after making transposition of seven lines, as suggested above.)

A sudden cutoff at Tarpley Neck would cause at least a temporary increase in the elevation of the water below the cutoff. The increased velocities above would cause excessive scour, and the material would be carried into the channel below, where the velocity would be reduced and sediment would be deposited, reducing the area of cross-section and raising the water surface.

The amount of increase in the elevation of the water below any cutoff on the lower Mississippi River and the length of time, perhaps months or even years, required to bring the channel below back to its former condition, thus completing the "hydraulic adjustments," would depend upon the increase in velocity as affected by the ratio of the lengths of the stretch of river before and after, and also, in a large measure, upon the characteristics of the material, as these would affect the rate of scour, the time required to form the cutoff and the loss in efficiency of the channel below, hence would affect also the amount that the surface of the water below the cutoff would be raised and the length of time required to bring about normal conditions below.

We have reason to expect many useful data from the experiments at the U. S. Waterways Experiment Station, but great care should be taken in interpreting results and drawing conclusions, especially where changes in velocities and cross-sections are caused by scour and deposit of material, presenting conditions that cannot be fully reproduced in the experimental model, and also where, as in this case, conclusions appear to run counter to the observations and conclusions of those who had devoted years of time to study and to observations of actual full-size experiments that were made by the river in the past.

I can see no good reason why stages should under all conditions be "increased below a cutoff by the same degree that they are reduced above," but conceivably the velocity and the characteristics of the material may have been such as to bring about that result in certain cases in the past, and the same result may reasonably be reproduced in the future under similar conditions.

It is also conceivable that conditions as to velocities and nature of material might prevail at the location of the cutoff which would cause heavy gravel to be swept into the channel below, resulting in a permanent elevation of the water level.

EDWARD FLAD,
Consulting Engineer, Member
Mississippi River Commission.

St. Louis, Mo.,
Dec. 17, 1931.

A Woman Lawyer-Engineer, Florence D. Potter

Sir—The sudden passing at Great Barrington, Mass., on Jan. 23, 1932, of Florence Dangerfield Potter, wife of Alexander Potter, consulting engineer, of New York City, comes as a distinct shock not only to her many friends but to her associates in legal and engineering circles, in which professions Mrs. Potter played a prominent part.

Mrs. Potter was born at Auburn, N. Y., and was educated at Auburn, Cornell and New York University (LL.B.), where she was president of her law class. After graduation she practiced law in New York City, being the second woman to be admitted to the bar in New York State.

Mrs. Potter's professional work was concentrated in the field of engineering law and contracts. Her practice extended to other states and to Mexico, where her activities broadened to the development and promotion of several water-power projects. Her work in connection with these projects presented problems that would try the courage and stamina of any man, and made prominent her gifts of fearlessness and resolution for the truth.

In her close association with her husband she played an important role in the preparation of the enabling legislation and contract for the formation of the first joint sewerage project to be undertaken by New Jersey municipalities. That this work was prepared with unusual foresight has been amply demonstrated. The original project was built under this contract in 1902, and the member municipalities operated thereunder until 1926, when a new contract, with no basic change other than to include five more municipalities, was prepared for the construction of supplementary works.

The greatest obstacle to the successful culmination of joint municipal projects was then, as it still is today, the determination of the proper proportion of costs to be borne by the participating municipalities. The difficulties of assessment of cost, involving many municipalities with as many individual interests, are innumerable, and Mrs. Potter's work in this connection—which has well stood the test of time, the project being now in successful operation for more than 30 years—has repeatedly stressed her basically sound and fair reasoning and her characteristic farsightedness and sagacity.

Those who have been associated with Mrs. Potter in recent years have been impressed by her infinite energy. Possessed of rare judgment, sound and fearless in her policies and constructive in her criticism, she was a source of constant inspiration to her associates.

ELSON T. KILLAM.

New York City,
Feb. 2, 1932.

Frame Analysis by Slope-Deflection Method

Sir—In your Dec. 10 issue Orrin H. Pilkey again brings up the point of what should be considered as the length of a member in statically indeterminate stress analysis. This is one of the most consistently controverted points of rigid-frame analysis. The writer feels justified in his use of the clear length for the following reasons: In the comparatively heavy mass of material constituting the joint (the mass bounded by the planes defining the clear lengths) the actual I on any section is so indefinite a quantity that there is practically no rational method for the inclusion of its effect, but its amount is so large that any distortion occurring here is negligible from all practical standpoints. Furthermore, since we are dealing with relative values of EI/L, the final moments would be practically the same by either method. Finally, any length that we may use (between the limits of clear span and center-to-center distance) is considerably more accurate than our knowledge of the actual *I* values would justify.

Regarding Mr. Pilkey's contention that the slope-deflection method does not allow the user to visualize what is happening in his structure, while the method of Professor Cross does, I disagree heartily. Distortion in itself is the only visual evidence of structural action. The slope-deflection method, actually calculating these distortions, does nothing if it does not tell the user what is happening in his structure. It is significant that the slope-deflection method antedated (1915) everything that has been done in this country on "exact" rigid-frame analysis. Before this time the only use of the angle of rotation at the joint or member-end as an unknown to be solved was in the special problem of secondary stresses as treated by the noted German authorities, Manderla and Mohr.

In "Engineering Studies No. 1," of the University of Minnesota (1915), G. A. Maney first generalized this method for application to all types of rigid-frame problems, including effects of joint rotation, member rotation and translation, and loadings of all types, not only at joints but between member ends. The general equation took the form

$$M_{AB} = M_{F\text{-}AB} + K(3R_{AB} - 2\theta_A - \theta_B)$$

For vertical loadings the form is

$$M_{AB} = M_{F\text{-}AB} - K(2\theta_A + \theta_B)$$

The first well-known specific application of this method was in Bulletin 80 of the University of Illinois experiment station on wind stresses, where Mr. Maney is given credit for the method used. Here the effect of loading between the ends ($M_{F\text{-}AB}$) is omitted.

The equation of the slope-deflection method that applies to rigid frames under vertical loading involves only three easily visualized conceptions:

1. When the rigid joints at the ends of a member *AB* are held fixed against rotation we have a zero case or starting point; the end-moments are the so-called fixed-beam moments.
2. As these fixed joints are allowed to rotate to a condition of joint equilibrium under the influence of all adjacent spans and loadings, a correction, which is a definite function of the angular rotation of *both* joints (θ_A and θ_B), is applied to *each* end.
3. Any angular twist, θ_A, or corresponding bending moment, applied at end *A*, causes only *one-half* of the bending moment at end *B* that it does at end *A*.

It is *only* because of this last fact that convergence is possible. This basis for convergence has been used by Allston Dana, designing engineer of the suspension bridge over the Hudson, in finding secondary moments in bridge members, and has been used for many years by Professor Maney, occurring in some of his earliest publications. Practically every engineer who has proposed a solution based on this fact—and there have been several in the past two years—has given the slope-deflection method credit for the conceptions that lead to their methods.

Professor Cross' method, however, gives no credit for the conception of either the fixed-beam moment as a starting point, or the 50 per cent reduction feature as a basis for convergence. Yet these two principles are all he uses. The first idea was strictly a slope-deflection concept, and the second, based upon the slope-deflection equation, was common property for the elimination of tedious work in the solution of the simultaneous equations of rigid-frame analysis since the early history of this subject.

The writer feels that the visualization of rigid-frame distortion, which is inherently necessary in the use of the slope-deflection method, has done more to simplify the whole subject to the profession than any other single thing, and is entirely unable to account for the origin of Professor Cross' method or any other "exact" method using successive approximations upon a basis other than this clear picture of rigid-frame analysis, which was first presented by Mr. Maney in 1915, and which not only antedates all these methods but has created the interest leading up to these several variations of the original presentation.

John E. Goldberg.

Chicago, Ill.,
Dec. 21, 1931.

Job Curves and Water-Cement Ratios

Sir—With the view to simplifying the plotting of job curves for reinforced-concrete construction, Inge Lyse (*ENR*, Nov. 5, 1931, p. 723) suggests using the reciprocal of the water-cement ratio as a variable rather than the water-cement ratio itself. He resorts to an old trick that is familiar to mathematicians—namely, expressing a hyperbolic relation between two variables x and y as a linear relation between the variables x and $\frac{1}{y}$.

Abrams' curve ***A***

$$S = \frac{14{,}000}{7^{\frac{w}{c}}}$$

over the range of water-cement ratios found in practice has the characteristics of a hyperbola. Over the practical range of water-cement ratios this equation can be represented by the formula

$$S = \frac{27{,}000}{G} - 1{,}600, \text{ or } G = \frac{27{,}000}{S + 1{,}600}$$

in which G is the gallons of water per sack of cement in the mix. The discrepancy between the two formulas is less than 2 per cent for water-cement ratios ranging from 4.5 to 8.5 gal. per sack of cement; and outside this range, lyin between 3.75 and 10 gal. per sack cement, the error is less than 6 per cen Expressing the water cement ratio. gallons per sack of cement is most easi understandable for the inexperienc man. To simplify the construction typical job curves it is necessary search in another quarter rather tha use a cement-water ratio by weight wit which he is not familiar.

For instance, assuming the typica job curve is of the exponential typ suggested by Abrams,

$$S = \frac{A}{B^{\left(\frac{W/C}{7.5}\right)}}$$

we can plot this formula as a straigh line on semi-logarithmic paper and gai the same simplicity that Mr. Lyse claim for his cement-water ratio.

F. T. Mavis

Associate Professor of Mechanics an
Hydraulics, State University of Iowa

Iowa City, Iowa,
Dec. 16, 1931

T-Flange Girders

Sir—The article by Messrs. Weiskop and Pickwo . (*ENR*, Oct. 29, 1931, p. 686), which described a new type of plate girder, using a T-section for each flange, is interesting to us because at the time it appeared our office had finished the design and was preparing the shop drawings of the structural-steel frame for an eight-story automobile building and storage warehouse 200x268 ft. (between 64th and 65th Sts. west of West End Ave., New York City), in which we utilized nine girders of a type similar to that proposed in the article. The building involves about 7,000 tons of steel, of which 1,100 tons are used in heavy plate girders and trusses in the first tier, required because of irregular column spacing occasioned by the tracks of the New York Central Railroad that run under the building. Above the first floor the column spacing had to be uniform (33½x24-ft. panels) to permit the efficient storing of automobiles.

The idea of using T-flange girders did not directly originate with me but was suggested by articles appearing in the April 24 and July 31, 1931 numbers of *Bautechnik*, describing a new plate-girder section, the basic principle of which is the utilization of wide T-sections (Peiner sections) for each flange, with welded web plates, as shown in Fig. 1.

The writer immediately investigated the possibility of applying this principle to the girder sections designed for the above structure. Girder webs in the building were limited from 48- to 60-in. depths on spans from 24 to 56 ft. requiring very heavy flange section, additional shear plates and increased number of flange rivets due to excessive rivet grips; in many cases flange and web rivets were required in four and

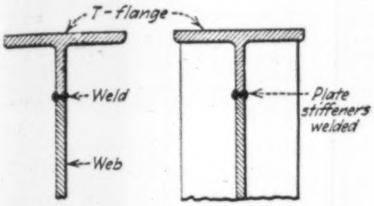


Fig. 1—T-flange girders with welded webs described in German magazines.

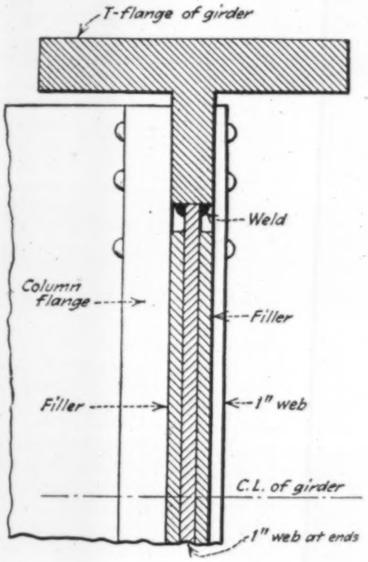


Fig. 2—T-flange-girder (studied but not used) detail where girder is continuous past a column.

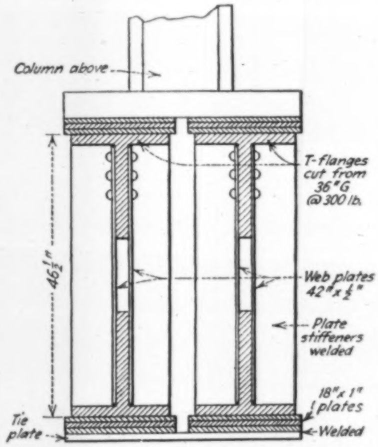


Fig. 3—T-flange girders used in design of warehouse in New York City.

six shears, using 1-in. rivets. In the majority of cases twin girders are used, with the webs straddling the columns and the inside flanges blocked out, excepting those girders that frame into other girders.

Study of the application of the T-flange-section principle showed that it was easily applicable to girders framing between other girders but undesirable when twin girders were necessary. In the latter connection some study was given the idea of welding a web at the ends of a girder between the stems of the split wide-flange sections, to carry this web and the regular outer web plate past the columns (Fig. 2); but the absence of published data on welding for such loading conditions prompted us to abandon this idea and to use regular flanges built up of angles for all girders straddling columns.

The T-flange girders finally used are nine in number, framing between other girders. The typical section of one of the girders (Fig. 3) uses T-flanges cut from 36-in. 300-lb. rolled sections with ½-in. web plates either side of the stem. Welded plate stiffeners are used as well as welded tieplates. Three 1-in. flange plates are used top and bottom at the maximum section of the girder.

The foundations for this building are completed, but steel erection is held up until spring. The architects are De-Pace & Juster, New York, N. Y., and the writer is consulting engineer.

James E. Geissberger,
Consulting Engineer.

New York City,
Oct. 30, 1931.

The Four-Cup Anemometer

Sir—At a recent meeting of the American Meteorological Society, it was announced that, commencing Jan. 1, 1932, all wind velocities would be taken from the old four-cup Robinson anemometer and not from the three-cup, as has been done since Jan. 1, 1928. Only corrected velocities will be published. The Weather Bureau in New York advised me that this ruling has gone into effect. This change can but add to the confusion already existing regarding published wind velocities.

Robins Fleming.

New York City,
Jan. 12, 1932.

Shopping for Bids

Sir—It seems that there are still people who are sure that "there ought to be a law" to correct any evil or apparent evil that crops up at any time or place. So now it is proposed that we shall have a law to prevent shopping of sub-bids by general contractors.

Admitting the evil that is inherent in shopping sub-bids, there seems to be no good reason for sustituting something that may develop into a greater evil.

In the first place, the purpose of letting a general contract is to place the responsibility for the execution of a given piece of work upon one man or one organization, and the general contractor is, in theory at least, responsible for all of the frailties and failures of his subcontractors, and none of their shortcomings absolve him from full accountability for the entire and satisfactory completion of the work.

With that fact in mind, and also the fact that many a general contractor has suffered losses because of withdrawal of bids by subcontractors, failure of subcontractors to include important items in their estimates and failure of subcontractors to complete work, it becomes apparent that every attempt to control or dictate the award of subcontracts is an unwarranted interference with the general contractor in the discharge of his contractural duties.

Then, too, there are many contractors who themselves are competent to, or who employ consultants who are competent to estimate an entire project from start to finish without even a taint of obligation to a sub-bidder and then award subcontracts and purchase materials under whatever market conditions exist after the award of the general contract.

The law proposed by Representative Goss, as reported in *Engineering News-Record*, Dec. 24, 1931, would deprive such contractors as these of a fair opportunity to use and profit by the ability that they possess.

A practice, such as suggested in the proposed law, has been used in private bidding many times in the past. Benevolent as it may seem in theory, in reality, instead of affording protection to subcontractors, it has actually been used as a club to beat down general contractors' bids.

When the general contractors have disclosed in their proposals the amount included under each subcontract item, the parties letting the contract have picked the lowest figure mentioned by any general contractor for each subcontract and naturally have been able to produce a total figure lower than any original contract bid. The next step, of course, was to call in the lower general-contract bidders one by one and attempt to hammer their figures down until someone had the job without the chance of making a profit.

As long as general contracting is acknowledged to be a reasonably satisfactory method of getting work done, the simplest possible form of bid is the one that is going to bring out the most truly competitive bids.

What is more necessary under present conditions and what would probably afford greater protection to material men and subcontractors than the proposed law is the authority, joined with the courage and honesty, on the part of all parties letting contracts, whether public or private, to reject all bids that are too low to permit of satisfactory completion of a job with a profit to the contractor.

Charles D. Dingman.

Palmer, Mass.,
Jan. 15, 1932.

NEWS OF THE WEEK

Lowest Responsible Bidder Defined in Proposed Bill

ONCE again Congress has before it the question of the definition of the lowest responsible bidder on government contract work. Last year a bill seeking to standardize public contracts was drafted which contained a provision authorizing the executive departments to award contracts to other than the low bidder in cases where they held such action would be to the best interests of the government. This provision was criticised by the comptroller general, who took the position that it would give the contracting offices too much discretionary power. The bill did not pass the House.

A redrafted measure has been brought forth this session which meets the approval of the comptroller general but which does not satisfy the executive departments. This time the lowest responsible bidder is defined as one who is able to show before the bids are opened that he is possessed of sufficient plant, equipment and financial resources to justify the conclusion that he is qualified to perform the construction work. In the case of the purchase of supplies, it is provided that the lowest responsible bidder must make a previous showing that he regularly manufactures or deals in the supplies described in the specifications.

Before the judiciary committee, which is considering the bill, E. W. Cushing, speaking in behalf of the executive departments, protested that under the bill the contracting officials would not be allowed to exercise any judgment in awarding contracts.

In its general form, the measure provides for uniform procedure in government contract work, including such matters as advertising for bids, forms of contracts, liquidated damages, filing of contracts, and payments. It also requires that preference be shown to articles and materials of domestic origin or manufacture.

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South Carolina to Resume Highway Work

Work on contracts involving about $5,000,000 in highway construction will shortly be resumed in South Carolina, it is expected, as a result of a bill passed last week by the legislature of that state which permits the state highway department to issue twelve months' notes at 6 per cent interest in payment of estimates. When the department became short of funds in December much of the work under way was stopped. Officials and contractors generally think the new method of financing will bridge over the present emergency. Some contractors believe that the proposed notes will be negotiable only at a heavy discount, but the consensus is that practically all of the jobs that were shut down will soon be in full swing again. The recent legislation makes no provision for financing new contracts with the short-term paper.

President Starts Movement to Bring Out Hoarded Money

Means of bringing into circulation the 1½ billion dollars now being "hoarded" were discussed at a meeting in Washington last week called by President Hoover and attended by representatives of organizations of all types. It was decided to set up organizations in every community, under the leadership of Frank Knox, publisher of the Chicago *Daily News*. These local committees will take systematic steps to restore confidence and will formulate a program to induce hoarders to allow their money to be put to work. The federal government is expected to do its full part in providing safe investments. Government bonds already are available in $50 denominations. Consideration is being given to the issuance of $5 savings stamps and there even may be a return to the thrift stamps of war time in 25c. denominations. Further details of the program have not been formulated.

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Newark's City Housing Plan Upheld by Court

The court of errors of New Jersey has upheld the decision of the state supreme court, affirming the action of the city commission in adopting an ordinance authorizing an agreement by the municipality with the Prudential Insurance Co. for the construction of modern housing facilities. By the terms of the agreement the Prudential company would acquire two blocks in the third ward of the city for home construction and the city, for $1,200,000, would acquire an inside strip in the development for use as playgrounds.

House Committee to Drop Amendments to Prevailing Wage Act

UPON assurances from the comptroller general that his department will accept the provisions of the recent executive order strengthening the provisions of the prevailing-wage law, the labor committee of the House of Representatives has about decided to abandon its effort to amend the act. It is still the intention of the committee, however, to press for action on legislation now being drafted for the purpose of applying the principle of the prevailing-wage act to flood-control and other work being done in the field by the engineers of the war, interior and agriculture departments.

The effect of the executive order issued by the President is to give government contracting officials greater authority in enforcing the act. Representative Connery, of Massachusetts, chairman of the labor committee, takes the position that this order makes it less necessary to amend the act, although he feels that it is lacking in some respects. He believes that a responsibility rests on the committee, however, to insure the workers on the flood-control project and on federal dams that they also will receive the wage rate prevailing in the locality where the work is done.

Since he feels that it may be difficult to determine the prevailing rate in sections where the flood-control work is being carried on, Representative Connery believes that it may be necessary to authorize the secretary of labor to determine what the rates should be, based on living costs.

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Survey Made by Real Estate Men Finds Homes Needed

ARMED with figures that show that 267 American cities will need new homes soon or have an actual shortage now, representatives of the National Association of Real Estate Boards have asked U. S. Senator Watson to speed the hearings on the proposed federal home loan banks bill, which would set up a new system to discount first mortgages held by financing institutions. Mr. Watson has set Feb. 15 as the date for resumption of the hearings.

Herbert U. Nelson, of Chicago, executive secretary of the real estate association, told the Senator that a country-wide survey made 30 days ago in 318 cities on the overbuilding question revealed the great need for the new banks. He said that the survey shows, contrary to public opinion, a normal supply of homes in key cities throughout the country which "all economists, bankers, and business men know means new structures will be required," and that direct testimony from these cities shows construction money is not available. No overbuilding is reported by cities of over 500,000. Mr. Nelson stated the survey brought out the "depressing fact" that in cities where there is an actual demand for new housing, first mortgage loans cannot be obtained and that this condition is responsible for the dormant condition of the real estate market which affects adversely so many other great allied businesses and trades. He said:

"City after city reports no local mortgage money available at all.

"There is a dearth of money for this purpose in every section of the United States.

"In large population centers 60 per cent of the surveyed cities are seeking loans for real estate mortgages. There is much less money for this purpose than a year ago in the same cities.

"It is clear that this goes hand in hand with the continuing inactivity in the residence construction market. Reports made by our local real estate boards in 318 principal cities show 84 per cent with a normal or short supply of homes, 13 per cent have an actual present shortage and only 16 per cent an oversupply."

Direct Federal Relief to Be Voted Down

As this is written, it seems certain that the LaFollette-Costigan proposal for direct federal relief will be voted down, as will the substitute proposition to authorize $375,000,000 for highway construction. Out of the controversy, however, it is expected that a proposition will emerge that will provide a large authorization for public works. It is believed that such a measure can be drafted along lines that will meet the approval of the administration.

The amendment to the La Follette-Costigan bill proposed by Senator Black, of Alabama, simply added to the proposal for direct relief the additional authorization for funds to be turned over to the states for roadbuilding purposes. The proposal differs in two important particulars from the federal-aid plan. The money would not have to be matched by the states and they would not be required to repay it. This money could be expended for the construction of roads through cities, irrespective of size, instead of following the 2,500 population limit of the federal-aid regulation. Except for these provisions the money would be handled as are federal-aid funds.

◆

Kentucky Reduces Salary Limits for Highway Commissioner

A law passed by the 1932 legislature of Kentucky provides a maximum salary of $5,000 a year to any employee of the state highway commission, commissioners being paid $20 per working day, with maximum of $3,000 annually. The act fixes the salary of the chairman of the commission at $5,000. Opponents of the law claim that with this limitation it will be difficult to obtain the right type of engineer.

Engineering Institute of Canada Holds Annual Meeting in Toronto

THE 46th annual convention of the Engineering Institute of Canada was held at the Royal York Hotel, Toronto, Feb. 3-5 with an attendance of about 400 delegates from all parts of Canada. The election of officers resulted in the election of Charles Camsell, deputy minister of mines, to be president for the year 1932, as noted last week. The new vice-presidents are: A. H. Harkness, Toronto; A. B. Normandin, Quebec, and S. C. Mifflen, Glace Bay, N. S.

C. G. Porter, the retiring president, in his annual address pointed out that a new outlet for scientific research lay in the conservation of Canada's natural resources. Engineering and science had been wonderfully successful in their application to industry, he stated. It is possible that a revolution is due in the field of economics and politics; if so, engineers and men of science should feel it their duty to assist economists and legislators in applying scientific methods in seeking solutions of their problems.

W. Hamilton Fyfe, principal of Queen's University, was the chief speaker at the dinner held Thursday evening. He made a forceful plea for the development of the cultural side of engineering education. Engineering skill, knowledge and intelligence, he said, had been exploited, to the detriment of humanity, not only in the production of armaments which threaten human security but by men who have made fortunes out of mass production of inferior and cheap machinery which tends to fetter the advance of science. Unless the engineer has an opportunity to develop his interest in all the manifestations of the human spirit, he is stunted as a human being and less effective as an engineer. In the past the education of engineers has been weak in this respect because the deans and the professors of the faculty of engineering have left this to the faculty of arts. Science is solving every problem that industry presents, and yet industry is languishing because engineering is in bondage to finance and there has been as yet no attempt to apply the beneficial methods of science to the problems of financial control.

Papers of special interest to civil engineers among the wide range of subjects covered at the meeting included the following:

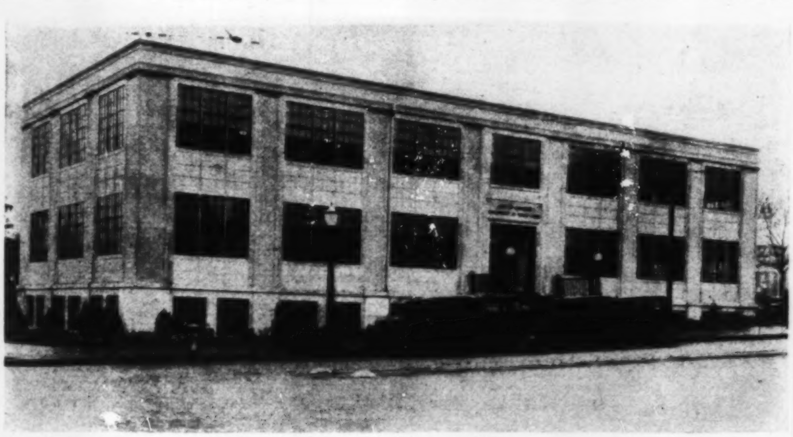
The new water-supply system for Niagara Falls, Ont., was described by H. C. Acres, consulting engineer, of that city. Raw water for the new supply is taken from the Niagara River above the Falls at the mouth of the Welland River behind the protection afforded by the Ontario power commission's intake. The water-supply intake leads directly to a treatment plant provided with facilities for coagulation, sedimentation, filtration and chlorination, whence it is pumped to the city system through a steel reinforced-concrete pipe 27 in. in diameter and 11,822 ft. long.

Two hydro-electric plants on the Lievre River in Quebec, the High Falls and Masson plants, were described by H. S. Ferguson, New York. The High Falls plant was completed in 1930, and construction of the Masson plant was begun in 1931. The latter plant is unusual in that a deep rock tunnel 25 ft. in diameter, carried to a depth of 145 ft. below tailwater as it approaches the power house, has been substituted for the more conventional penstocks.

Ice thrust at hydro-electric plants was the subject of a paper by Ernest Brown, dean of the faculty of engineering, McGill University, and George C. Clarke, vice-president, Fraser-Brace Engineering Co., Montreal. The paper outlined the results of a study made to determine what ice thrust should be provided for in the design of the Island Falls dam on the Churchill River. Temperatures of —50 deg. F. are to be expected in that part of Saskatchewan, hence the dam had to be designed for extreme conditions of ice thrust. On the other hand, the isolated location made the minimum safe section desirable because of the high cost of concrete. The studies showed that the high figures of from 40,000 to 50,000 lb. per linear foot of crest adopted for some dams is not justified—that a thrust of 10,000 lb. is all that need be provided for.

At the closing session the problem of rail and highway competition in transportation was discussed at length. S. W. Fairweather, director of the bureau of economics, Canadian National Railways, contended that there was too great disparity in costs to permit of anything like a complete substitution of motor vehicle for railway service. The bulk of the nation's land transport must remain with the steam railways. Whatever specific damage has been caused by motor competition has been more than compensated by the increased standard of living and the general increase in industrial activity. R. M. Smith, deputy minister of highways for Ontario, defended the provincial government's maintenance of highways on the ground that they were not subsidizing the truck and motor bus. W. A. McLean, consulting engineer, Toronto, argued that the railways themselves should coordinate railway and highway traffic, rather than appeal to the legislatures for taxation and regulation which would cripple highway traffic.

The Institute reports an increase in membership from 4,691 to 4,715 for the year 1931. Its financial statement shows a small deficit again this year. As a result, all salaries have been cut 10 per cent and publication of transactions and a year book in 1932 is to be omitted.



ALL-METAL OFFICE BUILDING IN RICHMOND, VA.

The distinction of occupying the first all-metal office building in the United States is claimed by the department of public works of Richmond, Va. In the building shown above, which was recently completed, a steel frame with open-web joists and steel plate floors is inclosed in aluminum. Steel casement windows that extend from the first floor to the roof are backed at the spandrels by aluminum sheet.

More Funds Sought for Relief of Unemployed Engineers

To arouse engineers of the New York metropolitan district to a recognition of the increasing need for funds for the relief of unemployed engineers the Professional Engineers Committee on Unemployment has called a mass meeting to be held at the Engineering Building, Monday night, Feb. 15.

Since the first of the year cuts in the staffs of city and county departments due to reduced appropriations, as well as cuts in the staffs of other publicly financed organizations and some private ones, have thrown more regularly employed engineers out of work and have ended temporary work provided for some of the unemployed. In view of this condition the engineers' committee is confident that the remaining months of the winter will bring increasing calls upon its resources.

To date the committee has raised in cash payments or pledges a total of $84,700. Work has been found for a total of 818 of the 1,727 men registered. However, the funds which the committee has raised to date were contributed by only 1,800 of the 12,800 engineers in the metropolitan district. Wages paid to men placed by the committee, either from the committee's own funds or from other relief sources, total over $190,900.

◆

Free Courses for Unemployed Engineers at Boston

To permit unemployed architects and engineers in the Boston metropolitan district to make profitable use of their idle time, the Massachusetts Institute of Technology is offering twelve courses free of charge to such men. The courses are in accounting, electrical distribution, electrical equipment of buildings, European art, foundations and soil mechanics, highway engineering, marketing, materials, mechanical equipment of buildings, production methods, reinforced-concrete design, and theory of structures. Courses run from Feb. 9 to May 25.

◆

Standard Grading Rules Adopted for Face Brick

Standard grading rules for face brick, which had been in process of preparation for more than a year and which will henceforth be used as the basis on which these brick are sold, were formally adopted by the American Face Brick Association at its recent annual meeting. Four classifications are made—uniform shade, mingled shade, substandard and cull. All first quality brick are placed in the first two classifications, which have stringent requirements as to dimensional variations, chippage, color and warpage.

The rules as adopted are based upon the standardized sizes of brick established in 1923. At that time a size of 8x3⅞x2¼ in. was made standard for smooth face brick, while a size of 8x3¾x2¼ in. was made standard for rough-textured face brick. It was recognized then, as now, that it is impossible to manufacture brick conforming exactly to these sizes, but no limitations as to the variation in sizes were worked out. The new rules cover this point thoroughly.

Acme Photo

BRIDGE WRECKED DURING DEMOLITION

Three workmen were killed on Jan. 12 when 40-ft. concrete slab of the Carroll Ave. bridge at Takoma Park, Md., fell as they were demolishing the structure. The crew had dynamited another portion of the bridge and had started to cut away the supports holding the remaining portion with acetylene torches and compressed air cutters when the supports buckled and the mass slipped forward and fell to the valley 75 ft. below. The work of demolishing the old bridge and building a new one is being done by the Forbes & Murphy Construction Co., of Baltimore. An investigation is being made by engineers of the state roads commission, but no report has been made.

Chicago Sanitary District Lays Off 200 Employees

Inability of the Sanitary District of Chicago to market its bonds has rendered necessary the temporary dismissal of 200 employees, including 75 whose duties were technical. By this action $45,000 per month is saved on the district's payroll. Most of the employees laid off were engaged in work supported by bond issues, and when bonds can again be sold it is expected that they will be reemployed.

A total of $2,048,000 of bond interest and principal is now in default. The district was unable to meet obligations totaling $1,519,000 on Jan. 1, and this amount was increased $469,000 on Feb. 1. All employees have been paid up to Nov. 15 only. Construction work has all been discontinued. As reported in *ENR*, Jan. 7, 1932, p. 32, no taxes have been collected by Cook County for many months.

Engineers Appointed on Pine Canyon Dam Project

Samuel B. Morris, chief engineer-sup intendent of the municipal water depa ment of Pasadena, Calif., has announ the appointment of Ross White and Ver L. Peugh, both of Pasadena, as constr tion engineer and resident engineer, r spectively, on Pasadena's Pine Canyon da project. Bids for construction of the da and an aqueduct are to be opened in Marc

Mr. White has had wide experience dams and hydro-electric projects. supervised construction of the Don Ped dam and the Exchequer dam, both in Cal fornia, and in 1928 he became the superi tendent of construction for the Aluminu Company of America on the Chute-a-Car dam and hydro-electric project in th Province of Quebec, Canada. He was that work two years and during the ne two years supervised construction of th Abitibi Canyon dam and hydro-electri works of the Dominion Construction C in the Province of Ontario. Last year h was engaged for special work for the wate department in the preparation of specifications for the Pine Canyon dam.

Mr. Peugh has been connected with th Pasadena water department since 1928 a field engineer. From 1922 to 1925 he wa a resident engineer on the San Francisc Hetch Hetchy project. In 1928 he went to the Los Angeles, Calif., County Flood Control District as an assistant engineer, and was engaged by the Pasadena water department in July, 1928.

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Los Angeles Wins Point in Owens Valley Water Dispute

One of the few remaining barriers t ultimate acquisition of all water rights in the Owens Valley by the city of Los Angeles, Calif., has been removed by the state district court of appeal in a decision granting the city and its board of water and power commissioners the right to vote 2,938 shares in determining officers and policies of the Owens River Canal Co. There is a total of 5,000 shares in the company, organized to serve water to individual land owners in the valley. The decision upholds a lower court ruling against Karl Keough, of Owens Valley, and others.

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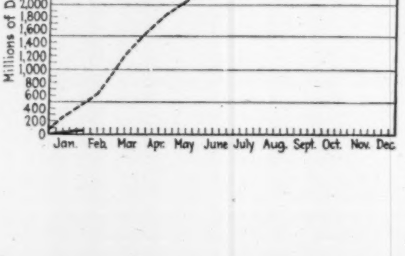
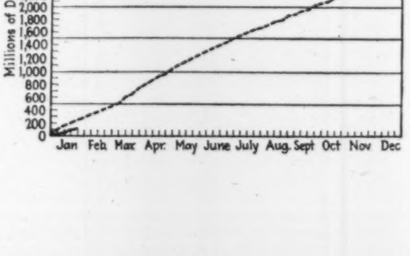
Capital and Contracts

No new capital was issued in the week ended Feb. 6, marking the second week since the beginning of the year in which no bonds or notes of any kind were offered.

Total new capital issued between Jan. 1 and Feb. 6 amounts to but $58,000,000, compared with $397,000,000 in the corresponding period of 1931.

Cumulative public financing totaled $23,000,000, against $35,000,000 private; in 1931 the totals were $103,000,000 and $294,000,000 respectively.





Personal Notes

Wayne C. Neff, of Ravenna, has been appointed division engineer for the fourth Ohio district, succeeding Charles E. Wild, who resigned recently to become city engineer of Akron. Mr. Neff has been with the department since 1920.

E. A. Kemmler, who was replaced as engineer of the bureau of highways by Clarence E. Wild when the latter was appointed city manager of Akron, Ohio, has been retained as an engineering adviser and consultant by Service Director Fred Clemmer.

Henry L. Howe, former city engineer of Rochester, N. Y., has been appointed to the new engineering position recently created to be known as mechanical and electrical engineer. The position of consulting engineer, formerly held by C. Arthur Poole, now city manager, has been abolished.

Edward D. Boyer, cement expert of the Atlas Portland Cement Co. and later the Universal-Atlas Cement Co., has opened an office as consulting technologist in New York City.

Warren T. Hannum, lieutenant colonel, Corps of Engineers, has been appointed a member of the board of engineers for rivers and harbors, to succeed Lieut. Col. Max C. Tyler, Corps of Engineers, relieved.

Frank J. Chester, vice-president of the Lake Asphalt Co., has been named director of highways of Allegheny County (Pittsburgh), succeeding Norman F. Brown, whose title was director of public works before the recent reorganization of the county government structure (*ENR*, Jan. 14, p. 72). Mr. Chester will have charge of highway, bridge and building construction and of highway and bridge maintenance.

Adolph J. Ackerman, formerly hydraulic designing engineer of the Aluminum Company of America in Pittsburgh, has been appointed structural engineer for the W. E. Callahan Construction Co., and Peterson, Shirley & Gunther, contractors on the Madden Dam project in the Canal Zone, and is at present located in their St. Louis office.

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Obituary

William B. Ross, of Halifax, N. S., a member of the engineering staff of Halifax harbor commission for the last four years, died on Jan. 23. Mr. Ross was 41 years old.

Charles B. Hurley, for 43 years a resident of Tacoma, Wash., died in that city on Jan. 30, at the age of 72. In 1903 Mr. Hurley organized the Hurley-Mason Co., general contractors, and constructed many buildings in Tacoma, including Fort Lewis during the World War.

Charles B. Campbell, a civil engineer in the city engineer's office of Watertown, N. Y., for the past six years, died in that city on Jan. 30. Mr. Campbell was born in England 71 years ago and was graduated from the engineering school of the University of Toronto and also held a civil engineering degree from New York University. At one time he was engaged in engineering practice in Montreal.

Hugh M. Balkam, of Milltown, N. B., died on Jan. 20, aged 74. After his graduation in civil engineering from the University of New Brunswick, Mr. Balkam engaged in civil engineering in northern Ontario in the construction of the Grand Trunk Railway. In later years he was an engineer in the construction of the St. John & Quebec Railway and also the transcontinental division of the Canadian National Railways. For some years previous to his death he was a consulting engineer for municipalities and public utilities in New Brunswick and Maine.

John Wesley Hackney, city engineer of Atlantic City, N. J., since 1897, died on Jan. 30. Mr. Hackney was born in 1866 and was graduated from Lehigh University in 1887. In 1890 he became associated with John P. Ashmead, of Atlantic City, and in 1892 formed with him the civil engineering firm of Ashmead & Hackney, this association continuing until 1897, when Mr. Hackney took over the duties of city engineer exclusively. He played an important part in the municipal planning of Atlantic City, among his achievements being the design and execution of the boardwalk and creation of the city's three million dollar gravity storm-sewer system. He was also consultant for Ocean City, N. J., in planning its sewer system. Mr. Hackney was a member of the American Society of Civil Engineers, the American Society of Municipal Engineers, the Society of American Military Engineers and the New Jersey Association of Professional Engineers and Land Surveyors.

SOCIETY CALENDAR

AMERICAN CONCRETE INSTITUTE, Detroit; annual convention, Washington, D. C., March 1-4.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, Chicago; annual convention, Chicago, March 15-16.

AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia; annual meeting, Atlantic City, June 20-24.

CONCRETE REINFORCING STEEL INSTITUTE, Chicago; eighth annual meeting, March 7-9, Atlanta, Ga.

NATIONAL PAVING BRICK ASSOCIATION, Washington; annual meeting, Chicago, Feb. 10-12.

ASSOCIATION OF HIGHWAY OFFICIALS OF THE NORTH ATLANTIC STATES will hold its annual meeting in Atlantic City, Feb. 17-19. Lee J. Grover, state highway commission, Trenton, N. J., is secretary.

ASSOCIATION OF PROFESSIONAL ENGINEERS of the Province of Nova Scotia at its annual meeting at Halifax on Jan. 22 devoted most of its discussion to means of securing amalgamation of all engineering organizations in the province. Officers were elected as follows: president, G. T. Medforth, Halifax; vice-president, F. R. Faulkner, Halifax.

FLORIDA SECTION, American Water Works Association, will hold its annual meeting in St. Petersburg in conjunction with the two-day short course on waterworks supplies, the short course on March 15-16 and the section meeting on March 17-18.

ILLINOIS SECTION, American Society of Civil Engineers, has elected officers for 1932: president, C. L. Post; vice-president, S. A. Greeley; secretary, F. G. Gordon; all of Chicago.

INDIANA SECTION, American Water Works Association, will hold its annual meeting at Purdue University, Lafayette, Ind., March 9-10.

KANSAS ENGINEERING SOCIETY at its annual meeting, Jan. 28-29 in Wichita, elected the following officers: president, L. K. White; vice-president, G. H. Ahlborn; secretary-treasurer, E. R. Dawley. Eighty-four, half the membership, were in attendance In the general meeting registration and unemployment of engineers were discussed. Among topics in the five sections were the following: Wichita disposal plant, flood control by channel straightening, welding, Kansas cement properties, transportation on the Mississippi River.

MEMPHIS ENGINEERS CLUB at its eighteenth annual banquet on Jan. 25 elected the following officers: president, A. D. McWhorter; vice-president, H. M. Clayton; secretary-treasurer, J. F. Ryan.

MONROE COUNTY CHAPTER, New York State Society of Professional Engineers, at its annual meeting in Rochester, Jan. 26 elected Charles W. Marvin, assistant city engineer, as its president for a third term. Howard S. Thomas was elected vice-president and Roy H. Hendrickson secretary-treasurer.

NATIONAL DRAINAGE, CONSERVATION AND FLOOD CONTROL CONGRESS will hold its 21st meeting at Louisville, Ky., Feb. 17-19. President B. F. Williams, state reclamation engineer, Austin, Tex., will present a paper, "Progress in Flood Control and Drainage," and other papers include: "Relations of Drainage, Flood Control and Inland Navigation," J. A. Harman, Peoria, Ill.; "Effects of the 9-Ft. River Channels," C. H. Young, Muscatine, Iowa; "Rights of Owners of Property Damaged by Dam Construction," Judge J. W. Fortune, Jeffersonville, Ind.; "Economics of Western Federal Irrigation," Porter W. Dent, U. S. assistant commissioner of reclamation; "Engineering Aspects of Conservation," Denzil Doggett, assistant state engineer, Indianapolis, Ind.; "Pymatung Reservoir," E. K. Morse, engineer of Pennsylvania water and power resources board; "Soil Loss by Erosion in Indiana," R. F. Wilcox, state forester, Indianapolis; "Drought Control," C. R. Knowles, superintendent of water service, Illinois Central R.R.; "Federal Relief for Drainage Indebtedness," E. V. Willard, state water and drainage commissioner, St. Paul, Minn.

NORTHWEST CONCRETE PRODUCTS ASSOCIATION at its annual convention in Longview, Wash., Jan. 22-23, elected officers for 1932 as follows: president, W. P. Hews, Yakima; vice-president, Charles Delling; secretary-treasurer, E. S. Warner, Tacoma.

SEATTLE CHAPTER, Associated General Contractors of America, has elected the following officers: president, James Murdock; vice-president, George Teufel; secretary, M. Phil Butler; treasurer, A. S. Downey.

SOUTHWEST ROAD SHOW and School and Western Tractor and Power Farm Equipment Show, scheduled to be held in Wichita, Kan., Feb. 23-26, have been abandoned on account of general business conditions. The management announces that they will be revived in 1933 and will probably be held the last week in February.

ST. LOUIS CHAPTER, American Institute of Architects, at its annual meeting on Jan. 26 reelected Eugene S. Klein president. Other officers chosen are: vice-president, Oscar C. Mullgardt; secretary, P. John Hoener; treasurer, Irwin Timlin.

UNITED ENGINEERING TRUSTEES, joint agency of the four founder engineering societies, has elected Harry A. Kidder, superintendent of motive power of the Interborough Rapid Transit Co., New York, president for 1932. Vice-presidents named are Harold V. Coes, of Ford, Bacon & Davis, and Arthur S. Dwight, of Dwight & Low Companies. Alfred D. Flinn will serve as secretary. On the board of trustees representing the American Society of Civil Engineers are Frank E. Winsor, of Boston; Charles A. Mead, of Newark, N. J., and Arthur S. Tuttle, of New York.

Materials Markets Slower

Sales of building materials are considerably under year-ago volume. Estimated per cent drop in freight-car requirements for the first quarter, compared with 1931, are: cement, 14 per cent; lime and plaster, 13; iron and steel, 13; concrete aggregate, 12; clay products, 11; prepared roofing, 11; lumber 10.

Cement—December figures on movement from mills show production 5,998,000 bbl., shipments 4,142,000 bbl. and stock 24,075,000 bbl. These represent decreases of 29 per cent for production, 27 per cent for shipments and 7 per cent for stocks. Prices dropped 5c. per barrel, to $2.10, at Minneapolis; 15c., to $1.85, at St. Louis; 20c., to $2.30, at Los Angeles.

Steel—Sales of fabricated structurals aggregate 10,700 tons a week, compared with 30,800 tons last year. Operating rate for whole industry is 39 per cent, against 46 per cent a year ago. Pittsburgh bars 10c. lower, to $1.50. Federal Trade Commission has completed report on steel rail prices which have not varied since Oct. 1, 1922.

Lumber—Mill stocks total 4,065,000,000 ft.b.m., compared with 4,768,000,000 ft. a year ago. Unfilled orders total 431,000,000 ft., compared with 653,000,000 last year. While stocks are lighter than in 1931, there is but 10.6 per cent already sold, compared with 13.7 per cent last year. Adjustment of production to orders is closer than at the beginning of 1931.

Paving Materials—Seasonal slackness is reflected by following reductions: granite blocks, 30c. per sq.yd. (to $3) at St. Louis, and $1 (to $2.75) in Kansas City; asphalt, 80c. per ton (to $14.60) in Atlanta, and $1 (to $14.50) in Cleveland, for bulk lots.

Wage Reductions in Building Trades Prevalent Throughout Country

WAGE agreements of two or three years' standing between building trades unions and employers are expiring in many cities throughout the country. In several cities, as contracts terminated, renewals were made at lower rates. In the remaining cities, where contracts will not expire until later in the year, there is marked determination evident among contractors to make reductions of approximately 25 per cent from former scales.

Estimates of the American Federation of Labor place present unemployment in the United States at 8,000,000 persons, the increase from January, 1931, to January, 1932, being 1,000,000. Federation figures indicate that the "worst" six trades, in percentage of unemployed, are: building, 62; musicians, 53; clothing and textiles, 44; general manufacturing, 37; water transport, 37; metal trades, 35. Local reports follow.

Buffalo—Plumbers voluntarily accept cut of $2 per day, to $10. Order affects 125 men. Water-main extension program will employ 2,500 men. Workers will be drawn from welfare department list and receive $5 per day, three days a week.

New York—By the 25 per cent cut announced by the Building Trades Employers Association for April 30, without consent of the unions, bricklayers will receive $1.50 per hour; carpenters, plasterers, plumbers, tile setters and asbestos workers, $1.25; helpers and laborers, 87½c. All trades are affected.

Philadelphia—Standardized wage of $1 per hour for all skilled building trades is proposed by the builders' exchange, unions dissenting.

Baltimore—Four-day schedule adopted for city laborers, in which each man loses one day's work in five. Additional men from ranks of the unemployed will be added to payroll to make up the extra day's work.

Washington—Local building trades unions charge contractors on school project with violation of the Bacon-Davis prevailing wage law. Affidavits state that workers were compelled to sign blank payroll slips.

Norfolk—Wages of all building trades reduced.

Memphis—Electricians voluntarily accept cut of $2 per day, to $8, with five-day week, until Dec. 1.

Cleveland—New scale proposed by employers' association cuts wages of steamfitters' helpers 30 per cent, common laborers 28 per cent bricklayers, lathers, plasterers, slate roofers and floor scrapers 15 per cent. The laborers' reduction makes wage lowest since 1914.

Columbus—County road workers cut 10c. per hour on Jan. 14, to 40c. Plumbers and steamfitters agree to a reduction of 25c. per hour, to $1.

East Liverpool, Ohio—Painters and decorators voluntarily accept cut of 25c. per hour, to $1. Agreement pending with bricklayers, electricians, plumbers and masons' laborers.

Marion, Ohio—Bricklayers voluntarily accept cut of 12½c. per hour, to $1.25.

St. Louis—Composition roofers struck Jan. 8 against wage reductions of 37½c. per hour, to $1.

Moberly, Mo.—Painters and decorators voluntarily accept cut of 12½c. per hour, to 87½c.

Lincoln, Neb.—Bricklayers voluntarily accept cut of 25c. per hour, to $1.

San Antonio—Carpenters' wage reduced $2 per day, to $7, with 5½-day week. Similar agreements with other trades foreseen.

San Francisco—All building trades mechanics now on five-day week. The 1931 wage schedule will be retained, since the change in hours of labor amounts to decrease in cost of approximately 9 per cent.

Spokane — Plumbers voluntarily take wage reduction of $5 per day, to $5. Employers had suggested a cut of but $2 per day.

COSTS AND CONTRACTS

ENR Index Numbers

Cost			Volume		
Feb.,	**1932**	**161.82**	**Jan.,**	**1932**	**121**
Jan.,	1932	162.48	Dec.,	1931	133
Feb.,	1931	196.61	Jan.,	1931	208
Average,	1931	181.35	Average,	1931	220
Average,	1930	202.85	Average,	1930	260
1913		100.00	1913		100

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of Feb. 11, with some comparisons, total as follows:

(In Thousands of Dollars)

	Feb. 11, 1932	Average of Last Four Weeks 1932	Average of Last Four Weeks 1931
Buildings:			
Industrial	$715	$2,041	$3,262
Other	6,496	8,350	16,314
Streets and roads	2,412	2,533	11,119
Other construction	1,033	5,707	12,111
Total	$10,656	$18,632	$42,807

Total, all classes, Jan. 1 to Feb. 11:	
1932	$125,866
1931	330,882

New Chicago Terminal Plan

The latest addition to the many plans for a new terminal station at Chicago, to provide for railroads entering from the south, is that proposed by J. D'Esposito, consulting engineer, who proposes a location at State St. and Roosevelt Road (Twelfth St.). This would serve the fourteen railroads now using the La Salle St., Dearborn and Grand Central stations. The passenger station, between State and Clark Sts., would have 26 tracks, and west of it would be a large freight terminal extending to Franklin St. It is stated that the property could be acquired for $4 per square foot, whereas the present sites are valued at $20 per foot, so that that plan would be financially practicable.

Concrete Pavement Yardage

Below is given a tabulation of concrete pavement yardage awarded in the United States during the month of January, divided according to roads, streets and alleys:

Roads	2,252,048
Streets	234,134
Alleys	38,031
	2,524,213

ENGINEERING CONSTRUCTION CONTRACTS REPORTED IN JANUARY, 1932

Thousands of Dollars (000 Omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States Jan., 1932	United States Jan., 1931	Canada Jan., 1932
Waterworks	$122	$121	$155	$209	$390	$284	$1,281	$5,431	$134
Sewers	211	2,447	....	339	46	165	3,208	5,079	423
Bridges, public	45	635	146	1,996	709	264	3,795	11,428	855
Excavations	....	25	6	63	....	229	323	2,908	226
Streets and roads	695	1,245	406	5,172	1,797	1,825	11,140	39,620	3,050
Federal government	484	1,427	3,846	1,361	7,742	1,556	16,416	10,576	....
Unclassified, public	240	2,747	25	135	84	226	3,289	16,134	89
Buildings, public	1,628	8,519	....	1,996	....	1,039	11,621	25,359	460
Total, public	3,257	17,166	4,584	9,710	10,768	5,588	51,073	116,535	5,237
Buildings, industrial	790	2,613	94	768	671	3,747	8,683	14,135	....
Buildings, commercial	1,750	21,120	822	2,300	150	1,364	27,506	54,316	2,940
Bridges, private	45	30	....	25	600	....	700	230	....
Unclassified, private	240	2,262	....	40	90	275	2,907	51,979	1,250
Total private	2,825	26,025	916	3,133	1,511	5,386	39,796	120,660	4,190
January 1932, 4 weeks	**6,082**	**43,191**	**5,500**	**12,843**	**12,279**	**10,974**	**90,869**	....	**9,427**
December, 1931, 5 weeks	12,083	53,086	8,012	18,266	25,073	8,611	125,131	....	4,722
January, 1931, 5 weeks	13,138	118,362	18,201	33,812	32,700	20,982	....	237,195	12,690

Construction Equipment and Materials

Paper Tubing as Form Spreader

A form spreader of paper tubing which fits over the usual tie rods and is used in connection with cast spreader cones is a new development of the Universal Form Clamp Co., 972 Montana St., Chicago, Ill.

Paper tubing form spreader.

The tubing is furnished in 4-ft. lengths to fit rods with diameters of $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$ and $\frac{3}{4}$ in. A heavy paper sleeve 6 in. long is placed over the splice in installations more than 4 ft. in length. The spreader cones are reamed out to provide a shoulder against which the tubing bears.

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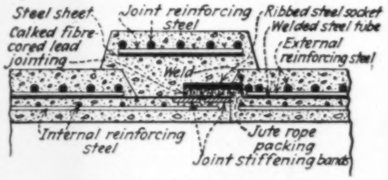
Pipe of Reinforced Concrete With Steel Core

Welded steel pipe with an interior lining and exterior covering of reinforced concrete, used successfully abroad since 1893, is to be manufactured and distributed in this country by the Bonna Pipe Company of America, Inc., 52 Vanderbilt Ave., New York City. Because of the extremely sturdy construction, pipe of this type is used most economically for high-pressure installations. The central steel tube is made of steel plates welded by the oxy-acetylene process to make a watertight main. The interior lining of concrete, reinforced by both longitudinal and spiral steel bars, is applied by the centrifugal process. The exterior covering, similarly reinforced, is cast in place and cured under air pressure to insure a dense coating. As a result, the pipe is strong enough to withstand the highest working pressures.



Section of Bonna pipe joint.

The standard joint used, shown in the illustration, is formed by two separate processes. For the inner joint, a ribbed steel socket is welded to the central tube of a pipe section to form a bell. The plain end of the adjacent section is then inserted into the bell and the annular space packed with tarred yarn and lead pipe filled with a fibrous core. Although this joint has sufficient tightness for all practical purposes, a second or external joint is added of reinforced concrete, the principal function of which is to make the two pipes practically a continuous beam with sufficient elasticity to allow considerable deflection. The finished joint is said to be as strong as, if not stronger than, the pipe itself.

Bonna pipe is furnished in a large variety of sizes and weights, and can be obtained not only in straight sections but also in bends and specials of every description. Advantages claimed include the absence of corrosion, an interior surface which improves in service, no expense for upkeep, absolute watertightness under any pressure, resistance to vibration and thorough protection against sudden changes of temperature and electrolysis.

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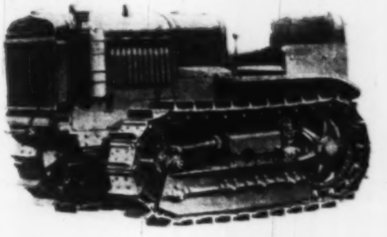
New Tractor and Truck Models



New crawler tractor.

Addition of a crawler tractor known as the model T-20 TracTracTor to the line of McCormick-Deering power equipment has been announced by the International Harvester Co., Chicago, Ill. The TracTracTor is especially well adapted for heavy construction work, such as road and levee building and maintenance, where the going is soft or rough and where ample power is required. All controls are within easy reach of the driver, who has an unobstructed view ahead. Particular care has been taken in the design to guard against dirt and dust. The bearings of the drive gear and pinion shafts are provided with specially developed diaphragm-type oil seals, and the track rollers and idler bearings are also protected with oil seals of new design. Forty ball bearings, of which seven are in the engine, are used in the machine. Transmission and final drive parts are mounted entirely on ball bearings. Power from the machine is available at belt or drawbar, and also through a power take-off for the operation of auxiliary equipment. The tractor operates with three forward speeds of $1\frac{1}{4}$, $2\frac{3}{4}$ and $3\frac{3}{4}$ m.p.h., and at 2 m.p.h. in reverse. The tread width is $41\frac{1}{2}$ in.; length of track ground contact, $52\frac{1}{2}$ in.; over-all width, 55 in.; and over-all length, 112 in.

Announcement has also been made by this company of a new International Harvester model A-3 six-cylinder $1\frac{1}{2}$-ton motor truck available with wheelbases of 136 and 160 in. The engine used develops a maximum brake horsepower of 54 at 2,700 r.p.m. Other features include single-plate clutch with vibration damper; four-speed transmission; flull floating, spiral bevel gear-type rear axle; mechanically operated four-wheel internal expanding brakes and cam and lever steering gear.

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New Publications

Electrical Equipment Development—A 44-p. analysis presenting facts and figures regarding the Westinghouse company is being distributed by Carreau & Snedeker, 63 Wall St., New York. The booklet, entitled "Ten Years With Westinghouse," traces the development of Westinghouse in the electric elevator, shipping, lamp, radio, household appliance and other fields.

Park and Estate Drives—The use of Bitumuls in country estate drives and walks and in parks is described in a well-illustrated 20-p. booklet issued by the American Bitumuls Co., 200 Bush St., San Francisco.

Barges and Dredges—Forty years' experience in building floating and terminal equipment, dock and material-handling installations, including dredges, barges, towboats, cranes and marine railways, is depicted in a fine 116-p. book published by the Dravo Contracting Co., of Pittsburgh. Fleet and shore equipment of all kinds is fully described.

Dredges and Centrifugal Pumps—Four new bulletins describing recent developments in its line of dredges and centrifugal pumping machinery have been issued by the Morris Machine Works, Baldwinsville, N. Y. Bulletin 140 covers centrifugal pumps for all purposes, dredges and steam engines. Small pumping plants for sand and gravel production are described in bulletin 141. Medium-duty dredging pumps and heavy-duty lined dredging pumps are featured in bulletins 142 and 143, respectively.

Installation of Asphalt Blocks—Methods of installation, including labor and materials requirements, of asphalt block paving and flooring are fully described in an 18-p. booklet issued by the Hastings Pavement Co., 25 Broad St., New York.

Direct-Mounted Pumps — Electrically driven direct-mounted types of self-priming centrifugal pumps are described in the new bulletin 37 of the LaBour Co., Inc., Elkhart, Ind.

Welding and Cutting Apparatus—The Air Reduction Sales Co., 60 East 42d St., New York, has issued a new 26-p. pocket-size catalog descriptive of Airco-Davis-Bournonville welding and cutting apparatus and supplies. The booklet lists specifications and prices on all types of welding and cutting torches, regulators, cylinder trucks and hose connections.

Steel Hydraulic Dredge—A hydraulic dredge of steel construction with distinctive new design features is described in a 12-p. bulletin P5 issued by the American Manganese Steel Co., Chicago Heights, Ill.

Venturi Meters—A short history of the Venturi meter, its principle of operation, typical installations and various types of recording devices are described in bulletin 260, just issued by the Builders Iron Foundry, Providence, R. I.

Railway Ditchers—Self-propelling ditchers of sufficient power and speed to handle work trains, thus dispensing with locomotives, are described in 6- and 12-p. bulletins of the American Hoist & Derrick Co., St. Paul, Minn. Two other bulletins deal with a ditcher mounted on a flat car and a crawler type of power shovel. These machines can be adapted for use as cranes, piledrivers and grab-bucket or dragline excavators.

Tractors—The new "25" tractor of the Caterpillar Tractor Co., Peoria, Ill., is the subject of a 32-p. catalog giving detailed description of the mechanism and special features of its caterpillar track and its power equipment.

Locomotive Cranes—The Burro crane for use in laying and loading rails, operating grab buckets, erecting steel and handling other railway work is illustrated in bulletins F-32, 33, 35, and 36 of the Cullen-Friestedt Co., 1300 South Kilbourn Ave., Chicago.

Bituminous Road Finisher—A 14-p. bulletin, 47-E, issued by the Lakewood Engineering Co., Columbus, Ohio, describes the application of the Lakewood finishing machine to the finishing of bituminous pavements.

Portable Conveying Equipment —The Jeffrey Manufacturing Co., Columbus, Ohio, has released a 52-p. catalog 530 describing all forms of portable conveyors for the handling of various types of materials.

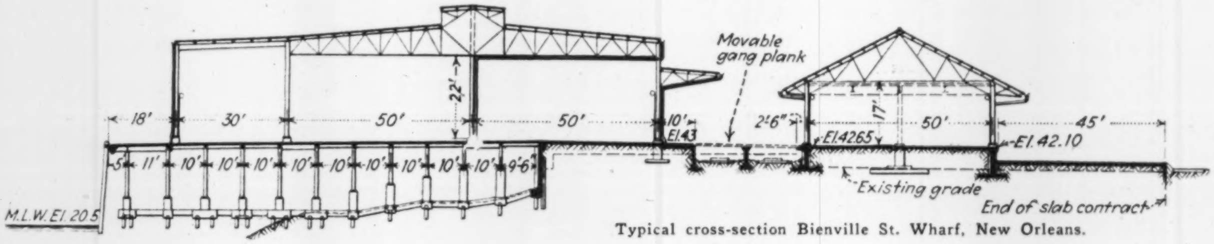
Current Construction Unit Prices

Slabs and Footings for Bienville St. Wharf, New Orleans

BIENVILLE ST. wharf is being reerected, following fire, under several contracts. In April, 1931, contract was let for concrete slabs, walls and piers, and grading levee back of wharf. Included also are foundations and ground floor of a city delivery shed and an office at the Canal St. end of the structure. The board of commissioners of the port of New Orleans furnishes additional fill delivered on cars at site.

Eight bids were received, ranging from $76,216 to $82,770, average $79,643. The principal unit prices are given of the lowest two bidders: (A) Concrete Construction Co., $76,216, contract; (B) J. V. and R. T. Burkes, Inc., $77,220.

	A	B
Excavation and backfill, 930 cu.yd	$0.40	$0.72
Grading fill already placed for wharf shed (lump sum)	450.00	283.00
Fill for roadways, etc., 5,800 cu.yd	.25	.49
Removal of plain concrete slab, 660 sq.yd	.10	.23
Removal of reinforced concrete slab, 200 cu.yd	.25	.23
Concrete Slab, 300 sq.yd	.25	.23
Concrete Work and Incidentals:		
Chain walls of levee platform, 170 cu.yd	14.50	18.75
Office foundations and slab, 200 cu.yd	15.25	14.35
Miscellaneous piers, walls and footings, 1,280 cu.yd	13.45	10.20
Slab on levee platform, 6 in. thick, 5,000 sq.yd	1.89	2.00
Slab on levee platform, 8 in. thick, 680 sq.yd	2.44	2.50
City delivery shed slab, 4,700 sq.yd	1.94	1.97
Concrete roadways, 7,450 sq.yd	2.44	2.57
Concrete sidewalks, 190 sq.yd	1.80	1.58
Granite curbs, 8 in. depth, 32 lin.ft	1.25	1.38
Granite curbs, 18 in. depth, 485 lin.ft	1.50	1.82
Granite curbs, 20 in. depth, 450 lin.ft	1.95	1.99
3½x3½x⅜ in. curb angles, 2,300 lin.ft	.50	.376
2½x2½x¼ in. curb angles, 7,430 lin.ft	.30	.225
12 in.–25 lb. curb channel, 750 lin.ft	1.20	.85
Totals	$76,216	$77,220



Typical cross-section Bienville St. Wharf, New Orleans.

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City Railway, Newark, N. J.

SECTION 2 of the City Railway for Newark, N. J., is being constructed in the bed of the Morris Canal. It connects with the subway structures of sections 1 and 3, now under construction. Work on the new section consists of earth and masonry excavation in open cut and under decking and construction of double-track steel bent and concrete-box subway sections. Contract was let Dec. 23, 1931, to J. Rich Steers, Inc., 17 Battery Pl., New York, for $1,268,994.

Principal items are 108,000 cu.yd. excavation at contract price of $3.99, and 26,000 cu.yd. class A concrete at contract price of $12 exclusive of the cost of the cement, and 2,300 tons structural steel at $73, the three items amounting to 72 per cent of the total cost.

Ten bids were received, and unit prices are given of the lowest three bidders: (A) J. Rich Steers, $1,268,994, contract; (B) Rodgers & Hagerty, Inc., New York, $1,348,569; (C) Clifford F. MacEvoy Co., Newark, $1,374,905. Engineer's estimate was $1,365,694. James W. Costello is chief engineer, department of public affairs.

	A	B	C
Earth excav. in open cut and under decking, for the railway and appurt., **108,000** cu.yd	$3.99	$3.85	$3.65
Earth excav. in open cut for **pipes, ducts, sewers, etc., 5,000 cu.yd**	2.79	6.90	2.75
Excav. of **masonry in place, 7,000 cu.yd**	4.04	3.85	2.00
Timber bulkheads and timber not otherwise provided for, 10 M. ft. B.M	93.60	88.00	100.00
Concrete piles cast in place, 20 ft. or less in length, 100	25.25	55.00	80.00
Concrete piles cast in place, 20 ft. in length and less than 30 ft, 150 lin.ft	1.89	2.75	4.00
Concrete piles cast in place, over 30 ft. in length, 100 lin.ft	2.00	2.75	4.00
Precast concrete piles, 20 ft. or less in length, 100, each	26.75	45.00	100.00
Precast concrete piles over 20 ft. in length and less than 30 ft., 150 lin.ft	1.89	2.20	5.00
Precast concrete piles over 30 ft. in length, 100 lin.ft	2.00	2.20	5.00
Steel pipe and concrete piles 20 ft. or less in length, 10	26.25	55.00	75.00
Steel pipe and concrete piles over 20 ft. in length and less than 30 ft., 100 lin.ft	1.89	2.75	4.00
Steel pipe and concrete piles over 30 ft. in length, 100 lin.ft	2.00	2.75	4.00
Portland cement used in concrete or in mortar, 43,000 bbl.	1.70	1.75	2.15
High-early-strength cement used in concrete or in mortar, 1,000 bbl	2.54	2.45	2.50
Class A concrete, exclusive of cement used, 26,000 cu.yd	12.00	12.25	13.60
Class B concrete, exclusive of cement used, 3,600 cu.yd	6.00	5.75	8.00
Sand used in mortar, 100 cu.yd	6.00	5.50	10.00
Common brick masonry, 200 cu.yd	30.00	38.00	50.00
Waterproofing without membrane, 1,150 sq.yd	.25½	.28	.28
Waterproofing, three ply, 24,000 sq.yd	.90	1.50	.95
Waterproofing, four ply, 7,000 sq.yd	1.18	2.00	1.08
Brick in asphalt mastic, 10 cu.yd	30.00	38.00	50.00
Structural steel, including anchor bolts and tie rods, 2,300 ton	73.00	78.00	80.00
Miscellaneous steel, 3,500 lb	.21	.22	.25
Steel for reinforcing concrete, 350 tons	73.50	125.00	100.00
Wire mesh, beam wrap or expanded metal, 5 tons	275.00	275.00	250.00
Steel sheetpiling, 650,000 lb	.05½	.04	.06
Subway gratings, 1,050 sq.ft	1.25	2.20	2.25
Miscellaneous iron castings, 50 tons	122.00	175.00	125.00
Cast-iron pipe, bell and spigot, straight, 130 tons	78.75	71.50	85.00
Railway ducts, single-way ducts, 34,000 duct ft	.23	.25	.30
New straight granite curb, 3,000 lin.ft	1.84	2.05	1.90
New curved granite curb, 550 lin.ft	2.31	2.35	2.50
New asphalt pavement, 21,000 sq.yd	1.27	1.55	1.40
Temporary bituminous macadam pavement, 1,000 sq.yd	1.05	1.35	1.50
New cement sidewalk, 85,000 sq.ft	.21	.25	.25
Temporary sidewalk, 1,000 sq.ft	.07½	.15	.10
12 in. vitrified tile pipe, 1,300 lin.ft	.98	1.50	1.20
15 in. vitrified tile pipe, 2,000 lin.ft	1.21	1.65	1.25
4 in. fiber ducts, 100 lin.ft	.60	.65	.50
Restoring granite block pavement, 600 sq.yd	1.58	1.65	2.50
Resetting curbing, 2,500 lin.ft	.58	.60	.85
Totals	$1,268,994	$1,348,569	$1,374,905